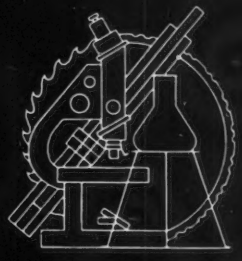
Forest Products Journal

SPECIAL PLYWOOD PRESSING EQUIP.—p. 13-A



Hardwood logging residues such as these could supply 120% of our hardwood pulpwood requirements. p. 1

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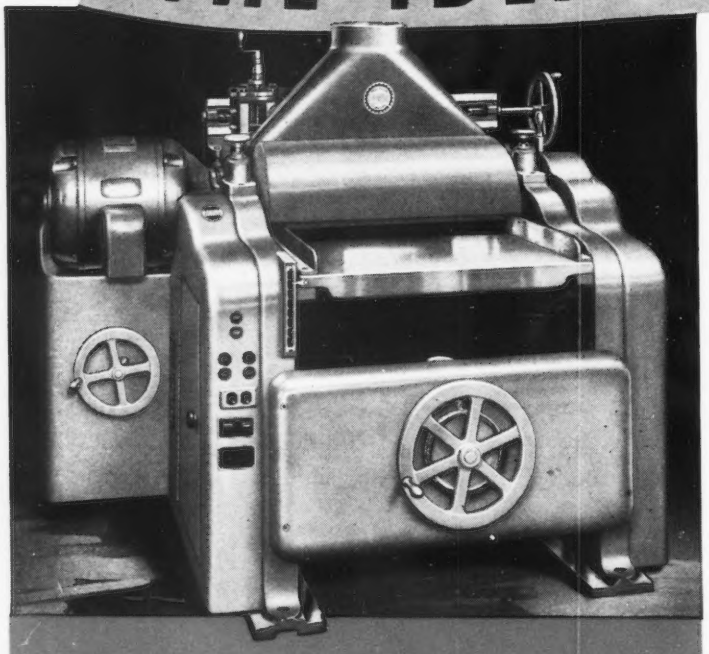
BUSS No. 44

THE IDEAL PLANER for ROUGH MILL CONVEYORIZED SET-UPS!



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THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Entered as Second-Class Matter, April 1952 at the Post Office, at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

Vol. VIII, No. 1 January, 1958

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IMPORTANT FPRS DATES

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Mar. 30–Apr. 1, 1958: Joint ASME, Northeast–Eastern Canadian Section Meeting, Syracuse, N. Y.

May 1–2, 1958: Northern California Section Meeting, Berkeley, Calif.

May, 1958: Pacific Northwest Section Meeting, Seattle, Wash.

May, 1958: Rocky Mountain Section Meeting

June 22–26, 1958: Twelfth National Meeting, Madison, Wis.

Final Request for Papers for the 12th National Meeting

Papers Needed for '58 National Meeting

Authors are urged to submit papers for the 1958 National Meeting. Authors should state the intended scope of their paper and other aspects that they feel will make their paper a valuable contribution for the National Meeting Program.

Communications should be directed to Mr. W. Jeter Eason, Nickey Bros., Inc., 2700 Summer Ave., Memphis 12, Tenn., to the National Office, or to Division Chairmen.

Announcing for 1958 . . . the Fifth Annual

Hitchcock's WOOD WORKING

Award of Merit

You are invited . . . to nominate some organization for the Hitchcock WOOD WORKING AWARD of MERIT Citation. You may nominate your own firm, or some other company, association or public institution that has been of outstanding service or has made a significant contribution to the promotion of wood and the utilization of wood during 1957.

Nominations must be received before February 15, 1958. Fill in the entry form below—any firm, association or institution is eligible—and send in your nomination right away.

NOMINATION FORM

I should like to nominate:

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(1) Less than 100 employees ____
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B. Associations

C. Public Institutions and Universities

D. Suppliers to the wood products manufacturing industry. This group includes suppliers of material, equipment and supplies.

Your Name _____

Organization _____

Address _____

City _____ State _____

Review of FPRS Operations, 1957

F. H. KAUFERT

ST. PAUL, MINN., DEC. 17.—The year 1957 has been a time of re-evaluation for the forest products industries. For our Society, 1957 has also been a time of readjustment. In the latter half of the year, we were particularly affected by the condition of the forest products industries. In spite of this, however, I am proud to report that 1957 will go down as another year of growth and stability for our organization.

Membership

Our paid membership and subscribers as of December 15 stand at 3498 compared to 3383 on November 9, 1956, or a net increase of 115 new members over this period. While this represents the smallest annual increase in recent years, it is heartening to record continued growth in the face of industry recession. In the year before, the net increase amounted to 325 new members.

A discouraging note was our inability to hold a group of existing members who were delinquent in their dues payment as of June 1. For example, of 372 delinquent members in July, we were able to sustain but 147 as of December 1. This compares with about 300 for the previous year.

Members are the Society's principal source of income and our 14 Section membership chairmen, the national membership chairman, and the Executive Office have redoubled their efforts to obtain a substantial increase in new members during the early part of 1958. In this drive, the personal assistance of all FPRS members is needed. We are asking each of the Society's present members to send a personal note with descriptive literature to at least one acquaintance whom he feels would benefit through membership in FPRS. By now, you have received the material describing this membership drive.

Finances

At this writing, 1957 looks like it will be a "break-even" year with a total income of $91,000 balanced by total expenses of $91,000. This compares with a total income of $88,000 and expenditures of $86,000 in 1956. These figures do not include contributions to the Executive Office Building Program or operations of the National Meeting.

FPRS' net worth after all obligations are met and with material holdings depreciated, will continue to be approximately the same as the 1956 figure, roughly $26,000. Of this, $10,000 is invested in our building site, $13,000 is deposited in a building and loan savings account, and about $3,000 is in equipment and cash.

Executive Office Staff

The staff of six full-time and two half-time employees has remained about the same as in 1956. We have, however, had personnel changes in the Editorial Department. During 1957, we lost our former editor, Edward H. Roche, and his assistant Mrs. Ruth Napp. We were fortunate in obtaining excellent replacements in our new editor, Robert H. Hamre, and his assistant, Mrs. Sandra M. Parrini.

Other members of the staff include the Executive Secretary, Frank J. Rovsek; Secretary and Bookkeeper, Mrs. Louise Dalton; Member Records, Mrs. Janette Arneson; New Membership and Employment, Mrs. Kenlyn Harris; Advertising and Publications, Mr. Arthur Heim; and Stenography, Mrs. Florence Van Kleeck.

We are indeed fortunate in the quality and loyalty of our Executive Office Staff. It has been a fine experience to work with them. It is with pleasure that I express to them the appreciation of all Society members for the fine job they are doing.

New Office Space

Because of the need for increased space in the U. S. Forest Products Laboratory, the Society's executive offices (located in the laboratory since 1947), were moved to temporary quarters about two miles from the laboratory. At our present location, 911 Regent Street, a slight increase in floor space and good facilities for storage were gained. When we moved, we were particularly fortunate in receiving some $3,000 worth of new furniture, the first major contribution of materials toward the new Executive Office Building, donated by the Wells Furniture Mfg. Co. of Laurel, Miss. The furniture is now in use, and will be transferred to the new office building when it is completed.

Executive Office Building Program

Perhaps the biggest news in 1957 was the decision taken at the January and June Executive Board Meetings to get the new office building underway during the calendar year. In December the contract was let to Mr. Leo Jenness, Madison builder, and the excavation was started in anticipation of completion before our 12th National Meeting at Madison, June 22–27, 1958.

The building was designed through the efforts of President-Elect, W. Jeter Eason, who is both an executive in the lumber industry and president of a leading Southern architectural firm. By the time this communication reaches you, the Executive Office Building Fund Drive, under the chairmanship of Southwest Regional Board Member Ray Berry, will have reached about $40,000. We are approaching our goal and with some added effort we should be able to raise an added $10,000–$15,000, and thereby make unnecessary the use of our reserves for completion of the building.

Numerous sizable contributions of materials and funds have been made during 1957. Space does not permit a listing of the many contributors, but I would like to express the deep and sincere gratitude of the Society to all donors at this time. It is hoped that companies and individuals will continue to subscribe to the project, which is expected to be completed in June 1958. We are still in need of funds to complete the building, and if you have not contributed, we urge you to do so. Contributions are tax deductible, and the fund drive has been extended to May 1, 1958. The Society is a duly-registered non-profit corporation. Therefore, any contributions (and dues) are deductible for income tax purposes by the donors in compliance with section 23 (O) and (Q) of the Internal Revenue Code.

Publications

The FOREST PRODUCTS JOURNAL continues to develop and has become one of the leading mediums of technical and non-technical information about wood and forest products generally. In 1957, we published a total of 1,002 pages compared to 1,054 in 1956 and 852 in 1955. In 1957, we published 149 articles compared to 161 articles in 1956. Plans for 1958 provide for a continuation of a high level of service to FOREST PRODUCTS JOURNAL readers. In 1957 we were able to reduce our manuscript backlog to the point where we now have 136 papers on hand for consideration for future publication.

Sections

High quality of leadership and administration has continued to exemplify the activities of our 14 Sections in 1957. All have held meetings as required by their charters. The fourteenth Section, the Rocky Mountain, was formally chartered in Denver, Colorado, May 6, with 29 members. They held their first technical meeting in that city on November 8, 1957.

Divisions

The Society's fourteen Divisions, whose contributions toward our overall progress must be considered on an equal plane with those of our Sections, continued to strengthen their organization during the year. Noteworthy was the establishment of steering committees and a pattern for succession of officers within a number of Divisions. Late in the year, a mail survey of our entire membership was made in order to determine each member's Division interest, the purpose being to develop the type and quality of technical sessions which will best serve members' needs, and to encourage active participation in the work of the Division. At this writing, a total of 1914 replies have been received, which break down as follows:

Subject Matter Division	Principal Interest
1. Wood Composition Board	235
2. Glues and Gluing	227
3. Lumber Manufacture	175
4. Veneer & Plywood	166
5. Wood Machining	157
6. Chemical Utilization	129
7. Wood Preservation	129
8. Logging	126
9. Wood Drying	89
10. Industry Education	83
11. Wood Finishing	75
12. Merchandising	74
13. Quality Control	61
14. Packaging	23

If you are interested in participating in the work of any of the 14 Divisions, or in submitting papers for possible Section or National meetings, please communicate with the Executive Secretary at Madison.

National Meetings

FPRS' 11th National Meeting, June 23–28, at Buffalo, New York, attracted a total of 750 and was characterized by excellent technical sessions, fine programs for the ladies, and progress in organization. It was a real credit to the work of an effective and efficient Arrangements Committee and the Society. A feature was the "Suppliers Exhibit", which displayed the products and services of 56 companies and educational organizations.

So went the record of 1957, a year of modest but steady progress. The task before us for 1958 will be even greater, and we will have to redouble our efforts if we expect to record substantial growth and improvement over 1957.

As I reach the half-way mark in my tenure as your President, I want to express my appreciation to all those who have helped in our progress, and to wish all a most prosperous New Year. —FRANK H. KAUFERT

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Scott Lumber Co., Inc., Burney
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National Homes Corp., Lafayette

KENTUCKY
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MICHIGAN
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Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven

MINNESOTA
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Minnesota Mining and Mfg. Co., St. Paul
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Wabash Screen Door Co., Minneapolis

MISSISSIPPI
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MISSOURI
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MONTANA
Intermountain Lumber Co., Missoula

NEVADA
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Western Electric Co., Kearny

NEW YORK
American Defibrator, Inc., New York
Behr–Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
The New Jersey Industries, Inc., New York
Oval Wood Dish Corp., Tupper Lake
Pierce & Stevens Chemical Corp., Buffalo
Reichhold Chemicals, Inc., White Plains
United States Plywood Corp., Brewster
The Upson Co., Lockport

OHIO
American Machine & Foundry Co., Shelby
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati

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Brooks–Scanlon, Inc., Bend
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Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
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Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer

SOUTH CAROLINA
Lightsey Brothers, Miley
Poinsett Lumber & Mfg. Co., Pickens

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Love Wood Products of Texas, Diboll
Southern Pine Lumber Co., Diboll

VERMONT
Beecher Falls Mfg. Corp., Beecher Falls

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American Marietta Co., Seattle
Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
International Paper Co., Long–Bell Division, Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma

WISCONSIN
Harnischfeger Corp., Port Washington
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh

ALASKA
Ketchikan Spruce Mills, Ketchikan

CANADA
B. C. Forest Products, Ltd., Vancouver
British Columbia Lbr. Mfrs. Assn., Vancouver
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
Knight Mfg. & Lbr. Co., Ltd., Meaford, Ont.
MacMillan & Bloedel Ltd., Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont.

FPRS NEWS-DIGEST

Volume VIII JANUARY, 1958 Number 1

Tentative 12th National Meeting Schedule Announced

The Role in Research of Industry–Education–Government Feature of Keynote Session

R. L. HILLER

A fully packed program is planned for registrants at FPRS' Twelfth National Meeting, June 22–27, in Madison, Wis., according to General Chairman Robert L. Hiller, who announced the tentative arrangements this month. The Hotel Loraine will be headquarters for the meeting, with the nearby Park and Edgewater Hotels providing supplemental facilities.

Fifteen technical sessions are planned, including the keynote session Monday afternoon, June 23, that will officially open the meeting. Fourteen subject matter division business meetings and three committee meetings are scheduled, as well as a wide range of social entertainment.

Office Building Dedication

The FPRS Executive Home Office Building, scheduled for completion in time for exhibition to the membership at the Twelfth National Meeting, will be dedicated on Sunday, June 22, at 5:00 pm. A program of the ceremonies will be announced later. National and state leaders in government and the forest products industries will be on hand.

Registration Starts Sunday

Registration, informal gatherings, committee meetings and a reception on Sunday, June 22, will start the week's activities. Registration will start at 2:00 pm., Sunday, and continue daily through Thursday. Fees have been set at $7 for members, $10 for non-members, and include admission to all technical sessions, and division and committee meetings. Ladies' registration fee is $5.

The reception Sunday evening will be sponsored by the host Mid-West Section, and will serve as a get-acquainted hour for registrants. Brief meetings are also scheduled that evening for the Industry-Education Committee, the Employment Committee, and the National Membership Committee.

Research Session Opens Meeting

The keynote session, officially opening the meeting, will have as its general theme the role of industry, education, and government in research. Nationally prominent speakers representing these three fields will be featured. FPRS President Frank H. Kaufert will open the meeting, and General Chairman Robert L. Hiller will make general announcements. Dr. J. A. Hall, Director, U.S.F.P.L., will extend an official welcome from the U. S. Forest Products Laboratory.

Following this, the 1958 Award of Merit Citations given in recognition of outstanding merchandising of wood and wood products will be presented by the Hitchcock Publishing Co., sponsors of the Awards.

The first Williams Memorial Wood Drying Lecture will also be presented at the opening session. Sponsored by the Moore Dry Kiln Co., the lecture is being prepared by Harry D. Tieman, international authority on dry kilns. The lecture will deal with dry kiln developments in the U. S. and Canada from before the first world war.

Fifteen Technical Sessions Planned

The technical sessions will again follow the pattern of presentation of papers, followed by floor discussion. The technical program is under the direction of W. Jeter Eason. The schedule for technical sessions is as follows:

Monday am—June 23,
Session I Wood Composition Board
Session II Wood Machining

Monday pm—June 23,
Session III Role of Industry-Education-Government in Research
(Keynote Session)

Tuesday am—June 24,
Session IV Veneer & Plywood
Session V Wood Preservation
Session VI Industry-Education

Tuesday pm—June 24,
Session VII Logging
Session VIII Glues & Gluing
Session IX Quality Control

Wednesday pm—June 25,
Session X Wood Composition Board
Session XI Wood Drying
Session XII Wood Finishing
Session XIII Chemical Utilization

Thursday am—June 26,
Session XIV Lumber Manufacturing
Session XV Chemical Utilization

Official Luncheon

The Official Luncheon Tuesday noon, June 23, will feature a high government official, formerly of the wood industry, who will soon be announced. The traditional FPRS Banquet preceded by the Paul Bunyan Cocktail Hour is scheduled for Wednesday evening, June 25.

U. S. Forest Products Laboratory Tour

Thursday afternoon will be devoted to tours of the U. S. Forest Products Laboratory, with major divisions visited to show the progress and type of work carried out by the world-renowned laboratory. Also, registrants will be able to consult with individual staff members at the laboratory from 8:00 am to 5:00 pm on Friday after the formal meeting ends. Consultations will take place by appointment.

Alternate Laboratory Tours

On Friday, arrangements have been made for registrants to visit laboratories within a 150-mile radius of Madison. Included will be the Institute of Paper Chemistry, Appleton, Wis.

Ladies Program

An interesting ladies program under the direction of Mrs. Ralph Simeone is in the planning stage.

Joint ASME, Eastern Canadian, Northeast Meeting Planned

Research and the Wood Industries is the tentative theme of a joint meeting of the Northeast and Eastern Canadian Sections that is being planned in cooperation with the Wood Industries Division of the American Society of Mechanical Engineers, March 21–April 1, at Syracuse, N. Y.

The two-day meeting will have several technical sessions, and will feature a visit to the Baker Laboratory at the School of Forestry at the State University of N. Y. Laminated Structures, and Finger Jointing and Edge Gluing will be the topics covered by the Eastern Canadian Section in the first technical session Monday morning. The second session in the afternoon will be sponsored by the ASME, and a number of new products and new applications primarily in the field of machining will be discussed.

On Tuesday morning, the Northeast Section will present papers on the Performance of Circular Saws and Heat Conductivity of Particle Board. A visit to the Baker laboratory Tuesday afternoon will end the meeting. A number of idea sessions, one on Glue Troubleshooting and another on Research are also planned. Banquet speakers have not yet been announced.

Imported Wood, Modifying Wood, and Handling Wood Featured at Northeast Meeting

Two new chairmen were named at the Northeast Section Meeting, October 31–November 1, 1957, at New York City. A. G. Battaglia succeeded Paul Graham as publicity chairman, and C. F. Van Epps became chairman of the Section's building fund committee for the new national office.

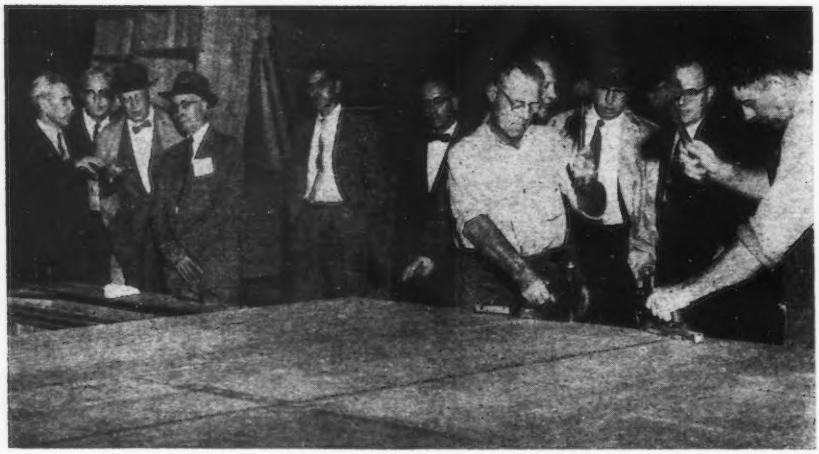
Papers on Imported Wood, Modifying Wood for Use, and the Handling of Wood Products, were featured at the meeting. The principal luncheon speaker was R. C. Sollenberger, Conveyor Equipment Manufacturers Assoc., who spoke on materials handling.

Three round table discussions with audience participation were held. Harry Rich, University of Massachusetts, lead a group analysis of problems facing users in the drying of wood. Frank Beyer, University of Maine, read a discussion on research in forest products. A discussion of the present status of particle board was lead by J. H. Brown, State University of N. Y.

New Officers Elected for Upper Mississippi Valley

New officers for 1958 have been elected for the Upper Mississippi Valley Section by a recent mail ballot, according to H. C. Crandall, outgoing chairman of the Section.

Walter B. Wallin, University of Minnesota, was elected Chairman; Paul H. Lane, U. S. Forest Service, Vice-Chairman; Wayne L. Meek, Minnesota Ontario Paper Co., Secretary; and Leonard A. Ropella, Roddis Plywood Corp., Treasurer.



Some of the Midwest Section Meeting participants are shown during a tour of Harnishfeger Homes Inc., part of the program of the recent Section meeting held in Milwuakee, Wis., Nov. 14–15, 1957. Viewing a plywood sheath panel are from l. to r.: E. A. Sloane, Harnishfeger; H. K. Von Maltitz, Karlton Machinery Corp.; J. J. Davis, Paine Lumber Co.; David Haile, Rock Island Millwork; J. F. Burrell, The Wood-Worker Magazine; and Dwight Bensend, Section chairman, Iowa State College.

Feb. 15 Set as Deadline for 5th Annual Hitchcock Award of Merit Nominations

Nominations for the 1958 Award of Merit Citations are now being accepted by Hitchcock Publishing Co., sponsors of the awards, according to Loren D. Jouett, Hitchcock's *Wood Working*. Any organization, association, or public institution that has been of outstanding service, or has made an outstanding contribution in promoting wood and the utilization of wood during 1957, may be nominated. Nominations must be sent to Hitchcock Publishing Co. by February 15, 1958.

Presentation of the "awards" will be made during the 12th Annual Meeting of the Forest Products Research Society, June 22–27, 1958, at Madison, Wis. This year awards will be given in five classifications: producers and manufacturers of wood products: a) less than 100 employees; b) more than 100 employees; associations; public institutions and universities; and suppliers to the wood products manufacturing industry.

New Procedures

This year's citations will be given on the basis of nominations rather than entries on a competitive basis as in the past. Organizations may submit their own nomination if they feel they are eligible. The official nominating form can be obtained by writing to Award of Merit, Hitchcock Publishing Co., 222 E. Willow Avenue, Wheaton, Ill.

Purpose of the Awards

Presented for the past four years, the awards are given for the purpose of recognizing and rewarding those who have promoted wood over other materials; to call attention, within the industry, to the need for public information and education; to publicize ways and means being used to prove the advantages of wood; and to combine the efforts of organizations to merchandise wood.

Recipients of the Award of Merit Citations in the past are: Monsanto Chemical Co.; Timber Structures, Inc.; St. Paul and Tacoma Lumber Co.; North Carolina State College; West Coast Lumbermen's Assoc.; Architectural Woodworking Institute; The Hardwood Plywood Institute; Pacific Lumber Co.; Consolidated Machinery & Supply Co., Ltd.; Kingsford Chemical Co.; E. L. Bruce Co.; Wood Office Furniture Institute; DeWalt, Inc.; Mississippi Products Co.; and Dependable Machine Co.

FPRS Education Program Adopted at NLMA Meeting on Recommendation of Committee

Six recommendations to bring career opportunities in the forest products industries to the attention of students were made by C. D. Dosker, chairman of the subcommittee on education, of the Building Code and Trade Promotion Committee headed by L. J. Carr at the recent NLMA convention in Washington, D. C.

"The Subcommittee is of the opinion," Mr. Dosker said, "that the marked decline of Forestry School graduates since 1950 should be recognized because of the need for technically trained people in our industry." He pointed out that in 1950 there were 2,321 graduating from such schools, while in 1955 there were only 850.

Mr. Dosker observed that "of those graduating in 1954, only 60 received degrees in wood utilization or wood technology—the training preferred and much needed in our industry for personnel in sales, production, and development fields." This proportionate decline, he reported, has continued in the years 1955 and 1956.

In the light of these facts, the subcommittee recommended to the Board of Directors through the Building Code and Trade Promotion Committee the following:

1. That in cooperation with the Forest Products Research Society, a booklet on Career Opportunities in the forest products industries and in the technological fields be prepared immediately for distribution to educational guidance and services of high schools and universities.

2. That a brochure be prepared immediately for distribution to educational guidance people that would contain a request for a third booklet on career opportunities.

3. That a booklet on career opportunities be available on a request basis to interested students.

4. Asked for the services of a full-time additional member to the Technical Department staff for the purpose of coordinating and implementing the educational program on the part of industry.

5. That the NLMA establish a permanent Special Committee on Education to continue the outlined program.

6. Requested that the Board of Directors extend the $3500 appropriation presently unexpended because of the detailed investigations necessary in regard to the preparation of a sound, workable program for the industry.

Other members representing NLMA and FPRS at the meeting included: Walter M. Leuthold, Chairman of the Board of NLMA; R. G. Kimbell, NLMA; Dr. J. S. Bethel, chairman, FPRS Industry–Education Committee; Dr. A. J. Panshin, past chairman, FPRS I–E Committee; Carl Rassmussen, Western Pine Association; G. F. Prange, Paul Koenig, and A. Z. Nelson, NLMA staff; and F. J. Rovsek, FPRS.

Photo Progress Report

Monthly Growth of the FPRS Office Building

A SOUTHERN VIEW of the building excavation site on December 24, 1927 is shown above. Workmen are putting plywood forms in place in readiness for pouring the concrete foundations. Concrete was poured on December 27, 1957.

BUILDING GETS UNDERWAY. Shown right are supervising architect Otto C. Heyer and building contractor Leo R. Jenness staking out the building site on December 16, 1957.

Siding, Roof Deck, Flooring and Paneling Contributed for Building

Since the last report to the membership in the December JOURNAL, several major material and cash donations have been made toward the FPRS building program.

Material Donations

Double tongue-and-groove 4 by 6 inch white fir roof decking, 10,500 feet in total, has been given by the Tahoe Timber Co., Reno, Nevada. Arkansas Oak Flooring Co., Pine Bluff, Ark., donated 2,150 feet of 25/32 by 2½ inch clear quartered red oak flooring. A contribution of 1,600 board feet of 1 by 6 inch clear, all heart, vertical grain tongue-and-groove V-joint siding has been given by the Pacific Lumber Co., Chicago, Ill., in addition to their previous cash contribution.

Prefinished plywood paneling for one room has been given by Roddis Plywood Co., Marshfield, Wis. Nickey Bros. Inc., Memphis, Tenn., has donated sufficient prefinished plywood paneling for the conference room and the auxilliary office. Hardwood Corp. of America, Asheville, N. C. has donated prefinished plywood paneling, moldings, and trim for two offices in either antique cherry, walnut or oak finish.

Cash Contributions

In recent weeks, major cash contributions have been made by the Simonds Saw and Steel Co.; Peter Cooper Corp.; Potlatch Forests Foundation, Inc.; International Paper Co.; C. H. Wentz Lumber Co. Ltd.; Engis Equipment Co.; and Black Bros. Co.

Other contributions were made by: Reisen Hardwood Lumber Co.; Maine Dowel Corp.; S. F. Stevens; W. J. O'Neil; D. W. Bensend; John Frey; A. A. Laun, Jr.; Walter E. Schalk; J. J. Allegretti; W. A. Kluender; Robert Archambeault; P. R. Farlow; R. S. Bacon Veneer Co.; The St. Marie Lumber Co.; Schmidt Bros. Inc.; and Carl Trinkle.

BUSINESS NOTES

● Lumber Production, Shipments, Stocks

Lumber production picked up in October 1957 compared with September 1957, but fell considerably short of the previous year's level. October output, estimated at 3,024,000,000 board feet, was five per cent above the previous month but 11 per cent below October 1956. Lumber shipments for the month were eight per cent above September but three per cent below last October. New orders were up seven per cent from September but down six per cent from October 1956.

For the first ten months of 1957, lumber output is estimated at 28,706,000,000 board feet, ten per cent below the figure of the previous year. Shipments and new orders both were slightly above production during the ten-month period. Unfilled orders declined five per cent during October 1957 and at the month's end were one per cent below the level of the previous year. Gross mill stocks on Oct. 31, 1957 totaled 8,611,000,000 board feet, one per cent below the end of September but one per cent above October 31 of the previous year.

NLMA Lumber Letter, Dec. 13, 1957

● New Construction Outlays—1957

Latest Commerce–Labor Dept. figures indicate that almost certainly dollar outlays for 1957 will reach an all-time high of more than $47 billion. November outlays of $4.1 billion boosted spending for the first 11 months of 1957 to $43.6 billion, more than $1 billion, or two per cent, above the previous year's level. Officials said that most or all of the increase could be attributed to higher prices for labor and materials, rather than to more work put in place.

NLMA Lumber Letter, Dec. 13, 1957

● Future Construction Outlay

Labor Secretary Mitchell estimates that new construction spending will have to pass $60 billion annually by 1965 in order to take care of a population close to 200 million. Mitchell predicts that highway outlays will be double the present $5 billion annual figure by 1965.

NLMA Lumber Letter, Dec. 13, 1957

● Housing Starts—1957

Total public-private housing starts in 1957 will exceed one million units for the ninth successive year, but private starts alone will fall below the million mark for the first time since 1949.

NLMA Lumber Letter, Dec. 20, 1957.

● Housing Outlook—1958

The Office of Construction Statistics of the Dept. of Commerce predicts a strong advance in total residential building for 1958; up 8 per cent in dollar volume, up to a total of 1,100,000 new nonfarm dwelling units, of which about 50,000 will be publicly financed. This compares with a probable total of a little less than 1,000,000 private units and about 50,000 public units in 1957.

It is likely that apartment units will constitute about a fifth of total housing starts in 1958, the largest proportion since 1949 when apartment-house construction was assisted by easy credit conditions and by special financing aids under the former Section 608 program of the National Housing Act.

The rising rate of rental-type home building at present may be attributed to expanding programs for rebuilding urban centers; anticipation of greater returns on rental investments; and a demand for convenient, central-city locations from the fastest growing adult segments of the population, young couples without children and the elderly.

Housing Trends, Dec. 1957

● Tree Planting

A billion trees were planted in the United States in 1957, 86 per cent on private lands and 14 per cent on public lands, according to the U. S. Forest Service. Twenty-five years ago, 26 per cent of all tree planting was on private lands, 74 per cent on public lands. The billion mark for 1957 is an all-time record, about 200 million trees above the previous high of 1956. The figure includes all forest, soil bank conservation reserve, and windbarrier tree plantings by private landowners, the forest industries, and public agencies.

NLMA Lumber Letter, Dec. 20, 1957

NLMA Releases New Wood Promotion Booklet

"Better Homes are Built of Wood" is the title of a new 32-page booklet published by the National Lumber Manufacturers Association to promote lumber and wood products for new home building and for home remodeling-expansion work. The publication discusses advantages of wood-frame construction, wood siding, wood windows, wood flooring, wood paneling, and other lumber items.

Intended for architects, engineers, builders, and the consumer public, the booklet is available as follows: single copies, free; two to 99 copies, 25 cents each; 100 to 499 copies, 20 cents each; 500 or more, 15 cents each, from the National Lumber Manufacturers Association, 1319 18th St., N. W., Washington 6, D. C.

Study of Circular Sawing Released by American Machine & Foundry Co.

"A Status Report on Research In the Circular Sawing of Wood", by James L. Lubkin, has been released by the Central Research Laboratory of the American Machine & Foundry Co. The report was designed to provide a technical foundation for improvements in the firm's woodworking products, and a basis for the development of new product lines in the cutting of materials.

The author attempted to collect, summarize, and critically evaluate the research results of the past 25–30 years. Emphasis on sawing, the author states in the forword, partly reflects the American Machine & Foundry Co. viewpoint, but also a world-wide interest and concentration on the subject. Discussion is generally limited to wood cutting references that give new results or confirmation and enlargement of previous results.

Subjects covered in the report are: circular saw performance as a function of cutting and feed speeds (feed per tooth and chip thickness); circular saw performance as a function of the relative size and orientation of sawblade and workpiece; and effects of tooth geometry, and number and pitch of teeth, on circular saw performance. Each of these categories contains more detailed breakdown and discussion.

A list of references and author index is included with the report. A second volume is planned for the future, and a tentative table of contents is listed in the present study. Supplements will be issued when the author feels revisions and extensions of the basic report are warranted.

Furniture Committee Formed to Launch National Publicity Program

Organization of a Furniture Development Committee to study means of launching a national publicity program for the furniture industry was announced recently by Harry Schacter and Paul Broyhill, co-chairmen of the committee. The committee was formed at a two-day meeting of leading representatives from all branches of the industry, at the Lake Shore Club, Chicago.

Forty-one spokesmen for individual firms in the furniture business attended the meeting. Total dollar volume of retail furniture business is estimated at more than $4 billions a year. Funds were pledged for immediate organizational work, and a seven-man steering committee to develop the proposed program was appointed.

Hardwood Grading Course Planned March 3–7 in Michigan

The second annual Hardwood Lumber Grading Course will be held March 3–7, 1958, at the Kellogg Center for Continuing Education on the Michigan State University campus, East Lansing, Mich. The five-day course is sponsored by the Dept. of Forest Products and the Cooperative Extension Service in cooperation with the National Hardwood Lumber Assoc.

Designed for those engaged in the production, selling, and buying or use of hardwood lumber, the course will also serve as a refresher for practicing graders. Study and application of grading rules will be discussed the first two days. The last three days will be devoted to group and individual grading.

The course will be limited to 25 and the registration fee is $25. More information can be obtained by writing to: Hardwood Lumber Grading Course, Continuing Education Service, Michigan State University, East Lansing, Mich.

Industrial Forestry Seminar to be Held March 24–April 4

The second West Coast Industrial Forestry seminar dealing with current problems in management of the forest products industries, which offers advanced training and discussion for executives, will be held March 24–April 4, 1958, at the University of California, Berkeley.

Topics to be discussed are: economic trends in forest industries, particularly on the West Coast; current income tax and general property tax problems in the industry; forest planting; wood product research and development; labor problems; and public relations. E. T. F. Wohlenberg, Professor of Forestry, Yale University, will direct the seminar.

Enrollment will be limited to 20, and a fee of $200 for the two-week course will be charged each participant. More information is available from Dean H. J. Vaux, School of Forestry, University of California, Berkeley 4, Calif.

Reichhold Announces 14th Plant

The fourteenth U. S. plant of Reichhold Chemicals, Inc., will be built at Hampton, S. C., Henry H. Reichhold, president of the company announced recently. First units to be built will include a large methanol terminal and facilities to produce formaldehyde. Production is expected to start about July 1, 1958.

'58 Student Summer Employment Program Launched

N. A. NORTON

The FPRS Student Summer Employment Program for 1958 has been launched, with 32 colleges and universities and 42 firms indicating a desire to cooperate. The program, now in its third year, is under the direction of Dr. Newell A. Norton, School of Forestry, Penn State University, Chairman of the FPRS Employment Committee.

The program enables wood industries to secure temporary summer employees, and gives forestry and wood technology students an opportunity to gain on-the-job experience which will be beneficial to them and their employers when they seek permanent positions upon graduation. Industries also report the program aids them in recruiting permanent employees. The summer training period gives an opportunity for evaluating the student's aptitudes and ability, while the students gain insight into the company's operations, which may be a factor in deciding job offers upon graduation.

Assisting Dr. Norton in coordinating the program are: Roy M. Carter, N. C. State College, Raleigh; Eldon M. Behr, Chapman Chemical Co., Memphis, Tenn.; Harvey H. Smith, California Forest and Range Experiment Station, Berkeley; Richard W. Pettersen, St. Paul and Tacoma Lumber Co., Tacoma, Wash.; and Eric W. Stark, Purdue University, Lafayette, Ind.

How the Program Works

Committee members contact wood industries in their region to determine their interest in obtaining student employees this summer. These lists of interested firms are sent to schools within the geographic area to give them first opportunity at filling local jobs. The lists are subsequently distributed to schools throughout the country.

Companies desiring to participate in this year's program are urged to contact the committe member in their region or the FPRS National Office, Box 2010, University Station, Madison 5, Wis. Students seeking summer employment should contact their faculty representative.

To date 42 firms have expressed interest in hiring one or more employees under the program. Last year, 32 institutions in the U. S. and Canada and 53 firms cooperated in the program.

Schools Cooperating

This year forestry schools and departments at the following colleges and universities are participating in the program:

Northeast: U. of Maine, Orono; U. of Vermont, Burlington; U. of New Hampshire, Durham; U. of Massachusetts, Amherst; Yale U., New Haven, Conn.; State U. of New York, Syracuse; Rutgers U., New Brunswick, N. J.; Penn State U., University Park; Laval U., Quebec; U. of Connecticut, Storrs.

Southeast: U. of Florida, Gainesville; N. C. State College, Raleigh; West Virginia U., Morgantown; Duke U., Durham, N. C.; Virginia Polytechnic Institute, Blacksburg.

North-Central: Iowa State College, Ames; U. of Michigan, Ann Arbor; Michigan State U., East Lansing; U. of Minnesota, St. Paul; Purdue U., Lafayette, Ind.

South-Central: Alabama Polytechnic Institute, Auburn; Louisiana Polytechnic Institute, Ruston; Louisiana State U., Baton Rouge; Oklahoma A & M College, Stillwater; Stephen F. Austin State College, Nacogdoches, Texas.

Northwest: U. of British Columbia, Vancouver; U. of Idaho, Moscow; Montana State U., Missoula; Oregon State College, Corvallis; U. of Washington, Seattle.

Southwest: U. of California, Berkeley; Colorado State U., Fort Collins.

Participating Firms

Firms that have offered to hire students this summer are:

Northeast: Protexol Corp., Kenilworth, N. J.; Osmose Wood Preserving Co., Buffalo, N. Y.; Armstrong Cork Co., Lancaster, Pa.; Saunders Bros. Co., Westbrook, Me.; Koppers Co., Pittsburgh, Pa.; Federal Equipment Co., Carlisle, Pa.; Cotton–Hanlon, Inc., Odessa, N. Y.; Paramount Furniture Co., Warren, Pa.; Jamestown Veneer & Plywood Corp., Jamestown, N. Y.; St. Regis Paper Co., Deferiet, N. Y.; The Borden Co., Philadelphia, Pa.

Southeast: Southern Plywoods, Inc., Greenville, Fla.

North-Central: Dunbar Furniture Corp. of Indiana, Berne, Ind.; Pierson-Hollowell Co., Inc., Indianapolis, Ind.; Joslyn Mfg. & Supply Co., Chicago,

Ill.; Brunswick–Balke–Collender Co., Muskegon, Mich.; Edward Hines Lumber Co., Chicago, Ill.

South-Central: Wood Mosaic Corp., Louisville, Ky.; International Paper Co., DeRidder, La.; Dierks Forests, Inc., Broken Bow, Okla.; Dierks Forests, Inc., Mountain Pine, Ark.; East Texas Pulp and Paper Co., Silsbee, Texas; East Texas Pulp and Paper Co., Jasper, Texas; The Mengel Co., Laurel, Miss.; The Mengel Co., Union City, Ind.

Northwest: J. H. Baxter & Co., Eugene, Ore.; Forest Fiber Products Co., Forest Grove, Ore.; Medford Corp., Medford, Ore.; Moore Dry Kiln Co., West Portland, Ore.; Snellstrom Lumber Co., Eugene, Ore.; Williamette Valley Lumber Co., Dallas, Ore.; Elmer & Moody Co., Inc., Seattle, Wash.; Harbor Plywood Corp., Aberdeen, Wash.; J. Neils Lumber Co., Klickitat, Wash.; Reichhold Chemicals, Seattle, Wash.; Simpson Logging Co., Shelton, Wash.; Western Pine Assoc., Portland, Ore.; The Borden Co., Seattle, Wash.; Douglas Fir Plywood Assoc., Tacoma, Wash.; Ketchikan Pulp Co., Ketchikan, Ala.

Southwest: Rockport Redwood Co., Cloverdale, Calif.; Scott Lumber Co., Burney, Calif.

In filing U. S. income tax reports, all FPRS members may classify dues paid as deductible expenses. Dues for 1958 should be paid promptly as delay causes added bookkeeping red tape and cost in the national office.

NAMES IN THE NEWS

R. H. BESCHER

B. M. RADCLIFFE

R. H. Bescher, Koppers Co., and past president of FPRS was one of 78 executives from all over the world who attended the nineteenth session of the Management Problems for Executives course this fall at the University of Pittsburgh. Participants in the course were selected on the basis of their outstanding accomplishments in business.

Professor Edgar W. E. Morath, D.Sc., a scientist of international repute in forest products technology and wood anatomy, has recently been appointed Director of Research and Development of the Board of International Plastics Ltd.

James M. Owens was recently appointed director of the Forest Products Division of the Business and Defense Services Administration, U. S. Dept. of Commerce, according to H. B. McCoy, BDSA Administrator.

Appointment of **Byron M. Radcliffe** as an associate professor was announced recently by A. J. Panshin, head of the Dept. of Forest Products at Michigan State University. Mr. Radcliffe will supervise the Residential Building curriculum with an enrollment of 150 undergraduate students.

Elected a vice president of Timber Engineering Co., is **Ralph H. Gloss,** structural engineer specializing in timber design. In his new post, Mr. Gloss will head the product sales division of TECO, and will also retain his position as secretary of the corporation.

Kingsland Dunwoody has recently been elected president of the S. A. Woods Machine Co., by the board of directors of the firm. Mr. Dunwoody, who succeeds the recently deceased Harry C. Dodge, was executive vice-president and general manager of the firm before his current appointment.

R. H. GLOSS

K. DUNWOODY

Recently elected president of the American Forest Products Industries, Inc., national sponsor of the American Tree Farm System, is **John B. Veach, Sr.,** Hardwood Corp. of America, Asheville, N. C.

Barrett Division, Allied Chemical & Dye Corp., has announced the appointment of **P. B. Mayfield** as Manager of Industrial Tar Products Sales. Prior to his appointment, Mr. Mayfield was associated with Allied Chemical & Dye as a consultant.

George A. Garratt, dean of the Yale School of Forestry, was recently elected president of the Society of American Foresters. He succeeds DeWitt Nelson, Sacramento, Calif.

J. B. VEACH, SR.

G. A. GARRATT

The appointment of **V. C. Otley** as director of sales for Industrial Tar Products and Paving Materials has been announced by Barrett Division, Allied Chemical & Dye Corp. Mr Otley has been associated with the firm for thirty years.

CHECKING THE CHARGE—Students enrolled in a one-week practical course in lumber drying prepare to break down a charge of ponderosa pine just removed from the kiln. The course was given recently at the University of California's Forest Products Laboratory, located at the Richmond Field Station. Seventeen lumber specialists attended, representing both softwood and hardwood producers.

Patents for "Stretching" and Stress Relieving Lumber Issued

The U. S. Patent Office recently issued two patents to Frank O. Higgins of New Orleans covering the "method and apparatus for stretching and stress relieving lumber". The Patent Office refers to the end result as a piece of lumber or veneer that is larger dimensionally when completely dried and finished than it was in its natural wet stage.

Application of the Higgins "wood-stretching" process reportedly does not measurably affect the thickness of the wood. There is also no change in the grain pattern or the surface of the lumber or veneer, and no loss of strength or durability.

The "process" was invented by Mr. Higgins, and the patents have been assigned to Higgins Industries, Inc. Higgins Industries reports that the process will be used in the manufacture of vener flooring products that will be priced competitively with asphalt tile and other resilient floor coverings.

European Forestry Tour Scheduled

A six-week tour of industrial forestry operations in seven European countries will be sponsored next summer by the Oregon State College school of forestry to give American forestry leaders an opportunity to observe and discuss the intensive forestry methods now employed in Europe.

College officials point out that many of the problems of future American forestry, such as management of second-growth timber and more complete utilization of trees, have been practiced by necessity in Europe for decades. Countries to be visited are Norway, Sweden, Denmark, Germany, Austria, Switzerland, and France. Present plans are to limit the party to about 35 persons.

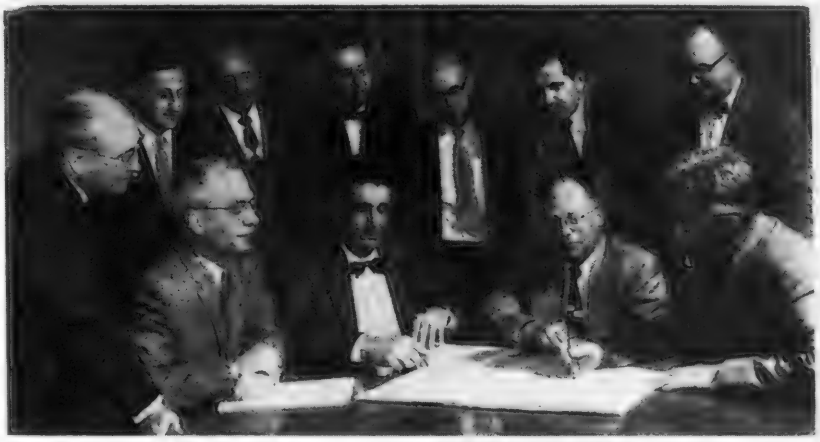
Graduate Statistics Offered at Oklahoma State University

The fifth Southern Regional Graduate Summer Session in Statistics will be held June 16–July 26, 1958, at Oklahoma State University, Stillwater. The work in statistics can be applied towards residence requirements at Virginia Polytechnic Institute, Oklahoma State University, University of Florida and at North Carolina State College.

The sessions are said to be of particular interest to research and professional workers who want intensive instruction in basic statistical concepts and who wish to learn modern statistical methodology, and to prospective candidates for graduate degrees who desire supporting work in statistics.

FPRS Salutes . . .

Men Who Are Contributing Their Time and Efforts for the Furtherance of the Society and the Wood Industry



John C. Killebrew and his committee—blueprinting the open house tours of the U. S. Forest Products Laboratory that will be a major feature of the 1958 National Meeting.

The committee shown above in the front row, l. to r. are: Otto C. Heyer, Division of Physics and Engineering; W. W. Mitchell, Division of Administrative Management; John C. Killebrew (chairman), Division of Research Publications and Information; Gene Fobes, Division of Timber Growth and Utilization Relations; W. G. Youngquist, Division of Physics and Engineering.

Back row l. to r. are: Joseph Chern, Division of Packaging Research; F. A. Simmonds, Division of Pulp and Paper; V. Peckham, Division of Timber Processing; J. W. Kulp, Division of Wood Preservation; R. A. Lloyd, Division of Wood Chemistry; L. V. Ersland, Division of Research Publications and Information.

Mr. Killebrew, chairman of the committee, has been closely associated with the Society for many years and has given freely of his aid in organizing past national meetings.

R. L. HILLER

Robert L. Hiller—master minding the 12th National Meeting. Keeping track of the 101 details and the 14 Divisions, all playing a part in the organization of an annual meeting, is Mr. Hiller's job as general chairman. By the time the National Meeting rolls around, Bob will have put in more than 12 months of work on the affair.

Organizational work is nothing new for Bob. He has served as National Membership Chairman and is now rounding out his third year on the National Executive Board as North-Central Regional Representative. Mr. Hiller has also held positions in the Mid-West Section and was responsible for the general arrangements for the Milwaukee National Meeting in 1952. Mr. Hiller holds a B.S. from the University of Minnesota School of Forestry and is a technical representative for American Cyanamid Co.

W. A. KLUENDER

William A. Kluender—is in charge of balancing the budget for the coming 12th National Meeting in Madison, June 22–27, 1958. As financial chairman for the National Meeting Committee, it's Bill's job to keep track of expenditures and incoming money from the National Meeting. Long a member of FPRS, Bill is now vice-chairman for the Mid-West Section and was treasurer during 1957. He is also a past chairman of the Upper Mississippi Valley Section.

Mr. Kluender holds a B.S. from the University of Wisconsin and an M.S. from North Dakota State College of Agriculture. He joined the C. & N. W. Railway System in 1946. He now directs the resource development program involving agriculture, forestry, minerals, and water.

G. G. GARLICK

Gardner Garlick—high attendance at the 12th National Meeting is Gardner's job. As publicity chairman, Gardner coordinates the efforts of his committee, responsible for all promotion for the meeting. He oversees the sending of information to wood industry trade journals, relations with the local press, and advance promotion among FPRS members.

Mr. Garlick, a charter member of FPRS, is a past chairman of the Great Lakes Section.

Vice president and technical director of Protection Products Mfg. Co., Mr. Garlick is a graduate of Western Michigan College, and a national leader in the field of wood preservation. He is an active member of the American Wood Preservers Assoc., and has published numerous articles on wood preservation.

John Flynn, Mattison–Greenlee Service Corp., Kenneth White, Greenlee Bros. & Co., Leonard Mitchell, Mitchell Moulding Co., and George Mitchell, Brammer Mfg. Co., at a recent demonstration of Greenlee Bros. & Co. new finger-jointing equipment. Leading executives and trade paper editors saw the machinery in actual production.

100 Attend Charcoal Meeting

About 100 charcoal operators and others from the Northeastern states interested in charcoal production and marketing attended a meeting, Nov. 21 and 22, 1957, at the Connecticut Agricultural Experiment Station in New Haven, sponsored by the Northeastern Wood Utilization Council.

Discussed at the meeting was the fact that several million dollars for advertising could not come close to duplicating the promotion of charcoal that is being done free through presentations in the press and on the air. Registrants were advised of a nationwide U. S. Forest Service survey which revealed that 36 large producers accounted for about 92 per cent of the charcoal made in 1956.

Experience reports by operators and a round-table discussion of marketing brought out many of the every-day operating factors of the charcoal business. The second day of the meeting was devoted to a tour of charcoal operations in Madison, East Hampton, and Union, Conn. Fred C. Simmons, Upper Darby, Pa., was chairman of the meeting.

Overlaid Plywood to be Produced at Converted Simpson Logging Plant

A $100,000 conversion of facilities to production of overlaid plywood at the Simpson Logging Company's Shelton, Wash., Olympic plant is now underway, according to C. H. Bacon, Jr., vice president and general manager. The conversion was initiated due to an extensive market study that revealed a growing demand for overlaid plywood.

The over-lay process fuses resin cellulose sheets to one or both surfaces of plywood panels to produce a plywood with a smooth and strong facing that is weather resistant and waterproof. High-density surfaces are used for concrete forms, and medium-density overlays are used for siding.

NEW PRODUCTS—LITERATURE

Water-Repellent Finish

The uses of a highly effective, penetrating water-repellent finish, which reportedly protects wood from grain raising, discoloration, warping and splitting, is discussed in a brochure available from Protection Products Mfg. Co., 2305 Superior Ave., Kalamazoo, Mich.

Hydraulically Powered Tractor

A new hydraulically powered tractor attachment that will lift a 600 lb. load, transport it and hoist it to an 11-foot height is now being offered by Shawnee Mfg. Co. The "Claw" attachment cradles the tractor with working mechanism located on the right and counterbalance provided on the left side of the tractor. It can be hydraulically rotated to position the load, and the arc of the main boom is 120°. Reach is 12 feet 10 inches.

Two Reichhold Bulletins

Two new bulletins are available from Reichhold Chemicals Inc. Technical Bulletin G-11 discusses Plyamul Adhesive for Woodworking Industry, and technical bulletin G-12 covers Diaron Adhesive Resin. They are available from Reichhold Chemicals, Inc. RCI Bldg., White Plains, N. Y.

(Continued on page 36-A)

EMPLOYMENT SERVICE

The FPRS Employment Service is operated without charge as a service to members. Companies or institutions with positions to be filled or individuals seeking employment may participate in this program by inserting a free ad in two consecutive issues of the FOREST PRODUCTS JOURNAL. Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Positions Offered

E–303—Chemist or chemical engineer wanted for West Coast concern to work in product development. Several years experience in either pulp, particle board, bark conversion or finishing preferred. Firm has expanding research and development department. (Jan.)

Employment Wanted

No. 450—Position desired in production or sales work. Will receive M. F. degree from Yale University in January 1958. Work at Yale has been primarily in forest products and wood technology, with emphasis on plywood and laminated wood, gluing and wood properties. Twenty-eight years of age. (Jan.)

No. 451—Position desired as production manager, assistant manager, or production superintendent. Experienced as production superintendent, pilot plant development, project and process engineering, and process control in the particle board, hardboard, wood utilization and pulp industry. Holds an engineering degree. (Jan.)

No. 453—Production or management position desired by person with 15 years experience in northern hardwood plywoods, stock panels, architectural, hollow and flush doors. Experienced in synthetic resin glues, quality control, products development and buying. Good at labor relations. Holds M. F. in Forest Products. Available in January. Desires Southern plant. (Jan.)

No. 454—Management position desired. Holds Ph.D. in Forest Engineering. Has two years research experience, three years of industrial experience, and two years of commercial experience. Specialized in plywood manufacture, wall- and particle-board development, quality control, and seasoning of wood products. Age 30. (Jan.)

No. 455—Position desired as project engineer in a particle or hardboard plant. Educated in Netherlands as a structural engineer. Experienced as piping design engineer for pulp and paper mills, design engineer and draftsman. Will accept any location. Age 29, married. (Feb.)

No. 456—Production on research development position desired. Recent graduate of the University of Minnesota School of Forestry in lumber merchandising and light construction curriculum. Would prefer east central Minnesota location or midwestern states. Available after June 1958. (Feb.)

POSITION OFFERED

Technical man for wood fiber insulating board plant in Pacific Northwest. To develop pulp and refining program and to do research work for product development. Unusual opportunity for rapid growth.

Send replies to:

E-302, Employment Service

FOREST PRODUCTS RESEARCH SOCIETY

P. O. Box 2010, University Station

Madison 5, Wisconsin

FPRS Forest Products Journal

Vol. VIII, No. 1
January, 1958

Utilization of Hardwood Logging Residue[1]

LELAND W. HOOKER

Forester, Michigan College of Mining and Technology, Houghton, Mich.

The development of processes for pulping dense hardwoods has created a vast source of raw material in the residue now left in the woods after hardwood stands are logged. The problems involved in estimating the amount of this residue, and in getting it out of the woods economically are discussed on the basis of studies in the Upper Peninsula of Michigan.

SELDOM DOES A TECHNOLOGICAL ADVANCE take place in one segment of an industry without its influence being felt to some degree in other segments of that same industry. The truth of this statement is demonstrated in the case of the recent development of processes for pulping dense hardwoods. The ability to make acceptable papers from hardwood fibers created, almost overnight, a vast new source of raw material. This, alone, is of immense significance in view of the increasing demand for pulp and paper products and the dwindling supplies of softwood pulpwood in many areas.

Silvicultural Aspects

The converse of new raw material sources, of course, is new markets, and it is from this standpoint that the forester or silviculturist views the hardwood pulping picture. It is known that young hardwood trees respond to early release from competition just as do the softwoods. The chief deterrent, however, to widespread early thinnings in hardwood stands has been the lack of suitable markets for the products of such operations. The forester, in many cases, can show that the cost of early cultural operations can be recovered ultimately in the increased value of the trees released, and the shortened period of growth to sawlog size. To any but governments, large corporations, and those who are holding timberlands in trust for their children, however, this argument is similar to the one that it is more economical to own a Cadillac because the turn-in value is high and the operating costs are low. Both arguments are sound, but most owners simply cannot afford the initial investment. The emergence of a large, stable market for small-sized hardwood trees holds the promise of widespread early thinnings that can only result in faster growth and better quality trees.

You will note that the last statement was qualified by the comment the development of markets "holds the promise" of widespread thinnings . . . This qualification was necessary because there are still some problems to be solved in getting small hardwood trees out of the forest and into the pulp mills. Since the solution of these problems is not the subject of this paper, it will do no more than just list some of them. For example:

1. During most of the year, young hardwoods are very susceptible to damage, and scarring the trunk or breaking limbs invites rot that will degrade the final product.

2. The density of young, even-aged hardwood stands often makes it very difficult to maneuver logging equipment without excessive damage to the residual stand.

3. The bark of some hardwood species is more difficult to remove than is that of most softwoods.

4. In young stands, the spreading crowns make it difficult, if not impossible, to fell trees in the desired direction. This complicates the skidding operation.

5. Many young hardwood trees are crooked, which makes them more difficult to handle or process with mechanical equipment.

The subject of utilization of the products of silvicultural operations will be left with the statement that the problems are recognized, and research

Fig. 1.—Hard maple top (class I residue) and broken-off small trees (class II residue). This photo illustrates some of the difficulties encountered in harvesting these residues.

[1] Presented at Session V, Logging, of the Eleventh National Meeting of the FPRS, held June 23-28, 1957, in Buffalo, N. Y.

The Author: Leland Hooker received his BS gree from the University of Massachusetts and s Master of Forestry from Yale University. He is a Forest District Supervisor for the Crossett umber Co. before he joined the staff of the lichigan College of Mining and Technology in 48. He is now in charge of research on timr harvesting.

Fig. 2—Ford Forestry Center, Michigan College of Mining and Technology, where the experimental work on this project is being done.

is in progress which, it is hoped, will provide the solutions to those problems.

Forest Utilization Aspects

The creation of markets for hardwood fiber has its impact on forest utilization no less than it does on silviculture. Most of us, I am sure, were shocked by the situation that existed a few decades ago when hemlock trees by the hundreds of thousands were cut down just so the bark could be utilized for its tannin content, and the logs were left in the woods to decay. The utilization of hardwoods is but little less shocking today, when trees are cut down just to make boards, while fiber is left in the woods to rot.

It has been estimated that approximately one third of the tree is left in the woods as logging residue, and that another third ends up as residue or waste product in the milling processes. A large part of this paper will be a discussion of some work that is being done by the Forest Products Research Division of the Michigan College of Mining and Technology on the utilization of hardwood logging residue.

Resource Survey—Local

It was recognized that, before any recommendations as to the utilization of logging residue could be made, or even before any plans for experiments in the harvesting of this material could be formulated, it would be necessary to get more detailed information on the amounts and kinds of residue being created. The mere statement that one third of the tree is left in the woods leaves several vital questions unanswered. A survey of the literature revealed that the only suitable work that had been done was a survey made in northern Missouri by the U. S. Forest Service a number of years ago, and the records of that work had been destroyed in a fire. Accordingly, a survey of hardwood logging residue in the Upper Peninsula of Michigan was conducted during the summer of 1955, by the Forest Products Research Division.

In planning the survey, it was decided that the questions to which answers would be sought should be these:

1. What volume of bark-free wood fiber is left in the woods for each thousand feet of sawlogs removed?
2. In what forms does this residue material exist, and what is the volume in each form?
3. How much residue material can be expected per acre?

Some basic decisions as to technique had to be made before the collection of field data could begin. For example, what should be the nomenclature of the various forms of residue? Another important decision concerned the method of volume determination to be used. It was felt that both weighing and liquid displacement were too cumbersome to be practical for the large number of samples required. This left measurement of length and diameter, which, while tedious when applied to limbwood, was still the only practical method for use in the field.

It was recognized that all potential users of residue materials would not have the same specifications for their raw material. In other words, some could use the entire amount, while others could use only that which met certain requirements as to size and quality of individual pieces. Accordingly, it was decided to collect the field data in such a way that resource estimates could be presented to a potential user whose requirements were for straight, surface-clear pieces two inches and larger in diameter, and one foot and longer in length. All diameter measurements would be expressed as inside the bark, so that volumes of wood fiber only could be reported. The adoption of these rather restrictive utilization criteria would have the added advantages of insuring that the results would be conservative, and making the measurement techniques somewhat simpler. From volume determinations made in this manner, the added amounts of material available to potential users whose requirements were less restrictive could be estimated with a fair degree of accuracy.

Since it is to be hoped that management of hardwood forests will become more widespread in the future, it was felt that the results of the survey would have more lasting value if data were taken only in managed stands. The residue created in the cutting of 500 sawlog trees in nine locations in the Upper Peninsula of Michigan was measured in the described manner with one-foot ruler calipers and bark gage.

It was found that there are two major classes of residue. One is that which is developed because of the form and growth characteristics of the tree itself, and consists of limbwood, top-butts, portions of the bole that were cut out, and long-butts. The other is that which is a function of the logging operation. This class includes trees pushed over or broken off by the trees being felled, trees cut in road and trail construction but which are too small for sawlogs, and logs and trees cut but left behind when the operation is finished. Class I, the tree-related class, is, of course, predictable with greater accuracy than is Class II.

Perhaps the most useful expression of volume of residue is that which is developed per thousand board feet of merchantable material, by species. In this connection, it should be noted that there are two possible expressions of merchantability—that amount which was actually utilized, and that which would be recorded by the timber cruiser under the heading "Gross Volume." It is the latter definition of "merchantable" that has been used throughout this study, because it lends itself to easy adjustment to any local standards of cull or utilization. Table 1 shows the amount of Class I (tree related) residue that can be expected to be found for each thousand board feet of merchantable timber cut. The

Table 1.—CLASS I RESIDUE BY SPECIES PER M FBM MERCHANTABLE VOLUME (SCRIBNER DECIMAL C, GROSS VOLUME)

Species	Limbs	Top—Butts	Long—Butts	Parts Cut Out	Total
		Cubic Feet*			
Hard Maple	38.2(50.8)	11.6	9.2	.4	59.4(72.0)
Yellow Birch	38.3(50.9)	10.9	2.5	.7	52.4(65.0)
Soft Maple	47.0(62.5)	10.0	3.1	--	60.1(75.6)
Red Oak	40.5(53.9)	11.1	5.5	--	57.1(70.5)
Beech	84.5	14.3	1.9	--	100.7

*Volume inside bark.

Table 2.—CLASS II RESIDUE PER M FBM MERCHANTABLE VOLUME (SCRIBNER DECIMAL C, GROSS VOLUME)

Category of Residue	Volume (Cu. Ft.)*
Trees Damaged or Pushed Over	2.9
Trees Cut for Roads and Trails	2.1
Logs and Trees Left in Woods	8.9
Total	13.9

*Volume inside bark.

Table 3.—HARDWOOD LOGGING RESIDUE PER M FBM (GROSS SCALE, SCRIBNER DECIMAL C RULE) IN A TYPICAL NORTHERN HARDWOOD STAND*

Category of Residue	Volume (Cu. Ft.)*
Limbs	33.8(44.9)
Top-Butts	12.5
Long-Butts	6.3
Parts Cut Out	.2
Trees Pushed Over	2.9
Logs and Trees Left in Woods	8.9
Cut for Roads and Trails	2.1
Total	66.7(77.8)

*Stand composed of 62% hard maple, 28% yellow birch, 3% soft maple, and 7% red oak.
†Volume inside bark.

similarity between species, with the exception of beech, is of interest, and reflects the similarity in growth form and characteristics.

The figures in parentheses are volumes available when all the residue in addition to that which meets the test of "straight, surface-clear pieces" can be utilized. The basis for these figures was arrived at by actually cutting up several tops according to the specifications used in the survey, and then weighing separately that material which was included in the survey measurements and that which was not. The figures in parentheses appear in the "limbwood" category because it is only there that significant differences occur.

Table 1 does not tell the whole story, because in addition to the Class I residue, there is always a certain amount of Class II material created in the form of trees knocked over, broken off, or otherwise damaged in felling, as well as those cut in road and trail construction but not utilized, and the logs left in the woods through oversight. This class of residue bears no relation to species, but to provide a sound basis for the prediction of the total amount of residue to be expected in any given operation, it must be prorated over the volume removed in that operation.

Since the volumes of material included in Class II are susceptible to wide variation depending on such factors as the type of logging, care exercised by the operator, intensity of cut, and season of year, any figure given must be simply in recognition of the fact that such residue is produced in every operation, and is not to be accepted with the same degree of confidence as figures for Class I residue. The volumes given in Table 2 are the averages of what was found on plots in all nine locations in which data were taken.

While Tables 1 and 2 provide the information necessary for predicting how much residue will be developed in any given logging operation, they do not indicate clearly what amounts of each class are present after logging in a typical northern hardwood stand. To show this picture, a typical stand has been synthesized on the basis of the occurrence of species on the survey sample plots. Since beech is a component of the stand only in the eastern part of the Upper Peninsula, it was omitted from the typical stand. Table 3 shows the amount of logging residue per thousand board feet in a typical northern hardwood stand.

When considering the problem of harvesting this residue material, the amount per acre is of particular interest. This is arrived at, of course, by multiplying the figures given in Tables 1 and 2 by the appropriate cut figure. Current practice in managed second-growth northern hardwood stands in the Upper Peninsula of Michigan, as shown by the survey, is quite uniform, with an average of ten trees totaling 2 M fbm being cut per acre. The amount of residue developed under these conditions is shown in Table 4.

A rule-of-thumb by which to predict the amount of residue that will be produced in any given hardwood logging operation, or to estimate how much is present as the result of logging already finished, is that, for each thousand board feet, gross scale, Scribner Decimal C, there will be 65 cubic feet of usable wood residue in straight, surface-clear pieces, or 75 cubic feet of wood residue if it can be used regardless of form.

All volumes have been expressed in cubic feet. The reason for this is that, because of its wide range of sizes and shapes, residue material does not lend itself to cording, with the result that the cord has little meaning as a measure of volume.

Fig. 3.—View of wheel tractor showing modifications for protection of machine and operator.

Fig. 4.—Skidding tractor with small A-frame mounted on hydraulic drawbar to give more lift to the load.

Table 4.—HARDWOOD LOGGING RESIDUE PER ACRE WHEN THE CUT IS 2 M FBM PER ACRE IN A TYPICAL NORTHERN HARDWOOD STAND

Category of Residue	Volume (Cu. Ft.)*
Class I	
Limbs	67.6(89.9)
Top-Butts	25.0
Long-Butts	12.6
Parts Cut Out	.4
Sub-Total	105.6(127.9)
Class II	
Trees Damaged or Pushed Over	5.8
Trees Cut for Roads and Trails	4.2
Logs and Trees Left in Woods	17.8
Sub-Total	27.8
TOTAL	133.4(155.7)

*Volume inside bark.

Resource Estimates—National

All of the data given so far is, of course, strictly applicable only in the Upper Peninsula of Michigan, because that is the only region in which measurements were made. The question is, then, "Can the figures obtained in this survey be safely applied to hardwood logging residue in other regions of the country?" In the absence of comparable data from other regions, and since hardwood trees are roughly similar in form wherever they are found, the answer is "Yes", with some reservations. If the conditions that cause variation in growth form are recognized, and it is understood how they operate to alter the figures in one direction or the other, these figures can be used as indications of what the residue situation is on a national scale.

Hardwood logging residue is not a minor resource. If it were considered solely as a source of raw material for the pulp and paper industry, there is enough wood fiber lying around in the forest today in the form of tops, limbs, and cull logs to satisfy 120 per cent of the present hardwood pulpwood requirements. Some of it, however, occurs in pieces of such size and shape that they might well find some higher value use than as chips for pulping.

Harvesting Experiments

The obvious question now is, "If all that fiber is lying out there in the woods, why don't we go out and get it? The timberland owner should be glad to get rid of it, and the loggers have already put in the necessary roads—it ought to be a snap." The answer, of course, is that it actually isn't as simple as that. In the first place, the form in which this residue material exists is such that it present problems in handling. In the second place, even if it could be gotten out of the woods at an economical cost, what could be done with it? It ranges in size from twigs to logs, much of it is crooked, and all of it has bark on it. In other words, plenty of residue is physically available, but much of it is economically or technically inaccessible.

The problem of handling hardwood logging residue from woods to a landing is being worked on currently by the Forest Products Research Division of the Michigan College of Mining & Technology, at its Ford Forestry Center at Alberta, Michigan. Here, typical hardwood logging conditions were duplicated on a five-acre plot, and experiments in skidding the logging residue were conducted. Since it was felt that speed in handling might be the key to successful skidding, a Ford Series 850 Industrial wheel tractor was used to skid to a landing one-half mile from the plot. It was found that, while this tractor operated at a speed of only 2.2 mph in the woods, it was capable of traveling 10 mph on a logging road with a full load.

Contrary to expectations, it was found that in nearly all instances it was possible to skid a hardwood top intact, without severing limbs, and without excessive damage to the residual stand.

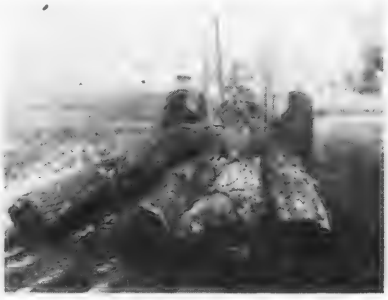


Fig. 5.—Wheel tractor skidding four 8-foot cull logs.

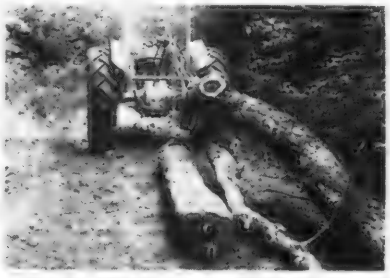


Fig. 6.—Wheel tractor skidding two tops and a cull log. Such loads were skidded ½ mile at speeds up to 10 mph.

The tractor used was not equipped with a winch. Many times, a hardwood top that was not heavy enough to constitute a full-capacity load for the tractor would be so bulky that it was not possible to hook on to another top or a cull log to complete the load. This meant that many times the tractor made the trip to the landing with less than an economical load. A winch is deemed just as essential to the employment of a wheel tractor as it is to a crawler tractor.

Based on the experience gained in this experiment, together with past experience with a larger wheel-tractor, the FWD Blue-Ox, an operation was set up employing four Ford-type tractors, each equipped with a winch, which would bunch for a large wheel tractor that would operate on logging roads. It is calculated that such an operation could move 10 to 12 tons of residue material per hour to a landing one-half mile distant at a cost of $2.20 per ton. It is hoped that an operation of this type can be tested in 1958.

With the movement of residue material to a landing at reasonably low cost, the problem is only partially solved. This residue is essentially in the same form and condition as it was when it was lying in the woods. It is felt that with volumes on the order of ten tons per hour coming into a landing, mechanical means for breaking it down can be economically employed, but there is still the problem of getting rid of the bark.

The bark problem is a serious one, but it is believed that the potentialities of logging residue as a source of hardwood fiber justify the considerable amount of research that is required on the bark problem. Three major avenues of attack are possible:

1. Develop a mechanical debarker that will handle crooked material from 2 to 24 inches in diameter in random lengths. The problems in connection with this line of attack seem insurmountable in the light of present knowledge.

2. Pulp makers can develop pulping processes that will economically utilize wood with bark attached. There are numerous problems to be solved in this line of attack, but when one views the developments of recent years, he is justified in the hope that something can be accomplished.

3. Suitable means for separating and segregating bark from wood after chipping can be developed. At present, this seems to be the most promising line of attack. Work is already underway, and more is planned in the field of bark-chip separation.

The importance of hardwood logging residue in relation to current and future supplies of raw material for the

pulp and paper industry justifies, even demands, intensive research on the problems to be solved before complete utilization can be realized.

Discussion

Lowell Besley (Pulp and Paper Research Institute of Canada): Do you have any data on the amount of bark included in this hardwood logging residue?

Mr. Hooker: The percentage of bark ranges from 27 per cent of the total volume on 2-inch diameter sticks to 14 to 15 percent of total volume on 24-inch diameter sticks. There is considerable variation between the bark on the several species, of course.

K. O. Roos (Booth Lumber, Ltd.): Did your measurement of residues include cull or defective trees left standing?

Mr. Hooker: No, it did not. The cutting was generally done in stands marked in advance by a forester, and we assumed that any such material left standing was left for some reason, such as spacing and crown cover to prevent the creation of excessively large openings.

Mr. Roos: Will chemical treatment of hardwood before cutting result in the removal of bark from the limbs and tops?

Mr. Hooker: I have no data on that.

F. C. Simons (Northeastern Forest Experiment Station): I can supply a little information. The effect of chemical debarking on topwood will vary by species. On beech, most bark will be shed or loosened after over-winter curing of chemically treated trees. Maple will not respond so well. With birch it will be necessary to split the bark longitudinally, but then it will come off quite easily, even from topwood. The Armstrong Forest Co. at Johnsonburg, Pa. is doing this splitting cheaply with a single router-type chain saw tooth mounted on a wooden handle. They have skidded some full tree material to the landing, including the tops, and they figure that approximately 85 per cent of the bark is lost in felling, skidding and bucking. But because the limbs are brittle, about 50 per cent of the limbwood is lost also.

James Conroy (Chain Saw Age): Why do you give your volume figures in cubic feet and tons, rather than board feet or cords? What is the ratio of man hours in logging to tons of material delivered at the landing?

Mr. Hooker: Pictures of the type of material we are dealing with indicate the impracticability of measuring it in board feet or cords. It is very rough, crotched and crooked, and varies in diameter from 2 inches to 24 inches and in length from 1 foot to 12 feet. In our synthesized commercial operation on this type of material, we figured on a crew of nine men, delivering 10 tons per hour to the landing, over an average distance of ½ mile. Consequently, production would be at the rate of 1 ton per 9/10 of a man hour.

W. R. Warner (Southern Lumber Co.): We do very little logging of hardwood down in our country, because our stands run about 90 per cent pine. However, we have studied the possibility of logging pine tops smaller than the standard 4 inches in diameter for pulp chip. We have located a debarker, made abroad, that can handle such material. We actually ordered one of these machines before we found that our local pulp companies would not accept chips from this top material. They said these topwood chips would make pulp too low in tear strength. We are still trying to get this prejudice straightened out so that we can go ahead with such operations.

Suspension Drying of Sawdust[1]

S. E. CORDER

Engineer, Oregon Forest Products Research Center, Corvallis, Ore.

An experimental suspension dryer was constructed and tested at the Oregon Forest Products Laboratory (now the Oregon Forest Products Research Center). Drying variables were studied to supply information for design of a sawdust dryer. Examples of potential applications of such a dryer are illustrated.

ABOUT A QUARTER TON (dry weight) of sawdust is developed for each thousand board feet of lumber sawed in sawmills. Some idea of the amount of sawdust produced in lumber regions can be had by noting that Oregon's sawdust amounted to more than 2 million dry tons in 1955. About a third of this sawdust was not used.

Water naturally present in growing trees is found in sawdust. The amount of water will vary with species, but for Douglas-fir, an average of about two-thirds of a pound of water is present with each pound of dry wood.

Sawdust now is burned for fuel without being dried, although fuel value is increased if some moisture is removed before it is burned. In looking for new and profitable outlets for wood residues, one finds many potential uses need dry particles or fiber. Fuel briquets, fruit packing, molded or pressed articles—all require dry particles or fiber. Some wood-composition boards are made with dry wood particles or fibers.

Drying Methods

Two major methods are common for drying granular products such as sawdust. In one method, the rotary drum dryer is used. This type dryer has a rotating horizontal cylinder through which passes the material to be dried. Hot gas flows through the cylinder where it comes in contact with and dries the product.

The other drying method can be termed suspension, entrained, or flash drying. The method will be termed suspension drying in this report. Suspension dryers have a drying duct, usually vertical, through which hot gasses pass. Wet material is fed into the hot gas at the base of the drying duct. The hot gas conveys the particles up the duct, drying them in the process.

Suspension dryers require less floor space than do drum dryers because the drying duct is mounted vertically instead of horizontally. There is little contact between hot surfaces and the material being dried, which tends to minimize the scorching of the product. Parry and others (1, 2, 3, 4)[2] in a study of drying fine coal, decided suspension drying was the cheapest method.

Although suspension dryers are in use (1, 3, 5, 6), there has been little published information on performance of these systems for drying sawdust.

[1] Based on a talk originally presented at the Pacific Northwest Section meeting of the FPRS, held October 25, 1955, in Vancouver, B. C.

The Author: Stan Corder graduated from Oregon State in 1950 with a degree in mechanical engineering. He joined the Oregon Forest Products Laboratory staff shortly after graduation.

[2] Numbers in parentheses refer to Literature Cited at end of the article.

The sawdust suspension dryer set up for the tests at the Oregon Forest Products Laboratory.

Since suspension drying appeared to be a simple, low-cost method for drying sawdust, the Oregon Forest Products Laboratory constructed and tested an experimental dryer in 1954. This report gives test results that should be useful in establishing design conditions for a suspension sawdust dryer.

Drying Principles

Drying is defined as removal of water by evaporation. Heat needed for evaporation usually is supplied by heated gas.

Important factors in drying are: 1. temperature of gas, 2. humidity of gas, 3. exposure time of product to drying conditions, and 4. physical characteristics of product.

In drying two wood products, lumber and sawdust, widely differing drying conditions prevail. Lumber must be dried for several days or weeks at low temperatures, say from 140 to 180° F., with close humidity control.

With sawdust, temperatures over 1,200° F., no humidity control, and drying time in seconds are possible.

The above comparison shows the importance of physical size in drying. Parry and others (2) have pointed out that the time required to heat a spherical particle varies as the square of its diameter. A sawdust particle of 1/20-inch diameter will be heated in about 1 second, but a particle of 1/8-inch diameter requires 5 seconds, and a 1-inch particle takes about 6 minutes to be heated. Since particles are in the suspension dryer only a few seconds, it is apparent that this drying system is limited to drying small particles. Fleischer (7) has shown that, for wood particles less than 1/4-inch thick, heat transfer, rather than diffusion, governs rate of drying.

Exposure to high temperatures: The question naturally arises, "How can a heat-sensitive material, such as sawdust, resist temperatures over 1,000° F.?" The answer is simple: the product does not reach the high initial temperature of the gas because of included water. For example, if a pan of water is heated, the water will rise in temperature, start to evaporate, and finally boil at 212° F. If the heat supplied to the pan is increased, the water boils faster, but without rise in temperature.

An analogous situation occurs when sawdust is dried. Water is in wet wood particles. Since evaporation usually takes place at or below 212° F., the sawdust will not rise far above this temperature until the water is evaporated. At low moisture content, water is associated with wood in "bound" form, and the temperature of the wood may rise above 212° F. An explanation of bound water is beyond the scope of this paper, but may be found in reference (8).

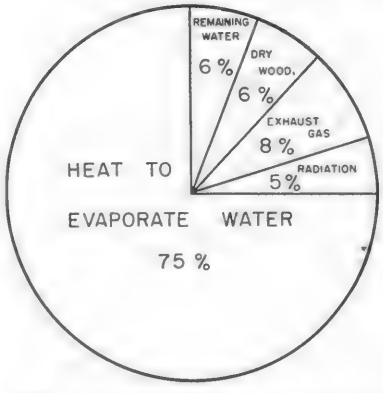


Fig. 1.—Heat balance for dryer at: an air rate of 4,180 lb per sq ft per hr; an air to sawdust ratio of 1 to 1; initial gas at 1,200° F.; initial moisture content of 67 per cent; final moisture content of 33 per cent.

Heat Balance for the Suspension Dryer: Thermal efficiency generally is defined as useful heat obtained divided by total heat added to a process. There is some disagreement on definition of useful heat for a dryer. Heat to evaporate moisture is considered useful, but what of heat to raise the temperature of wood and water remaining in the wood? In this report, only heat to evaporate water was considered useful, and efficiency was calculated accordingly. A typical heat balance for the test dryer is shown in Fig. 1. A total of 1,110 British thermal units theoretically are required to evaporate a pound of water at 70° F. to steam at 212° F. Efficiency, therefore, was determined by dividing 1,110 by the total heat added per pound of water evaporated. For simplicity, additional heat to evaporate bound water was not calculated.

Total heat added to the suspension dryer was determined by air rate, specific heat, and temperature of the gas. Heat added was divided among the following: raised temperature and evaporated part of water, raised temperature of dry wood, raised temperature of moisture remaining in wood, discharged in exhaust gas, and lost to radiation and convection.

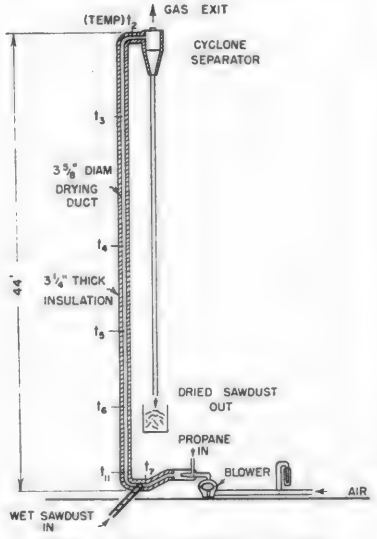


Fig. 2.—Experimental suspension dryer for sawdust.

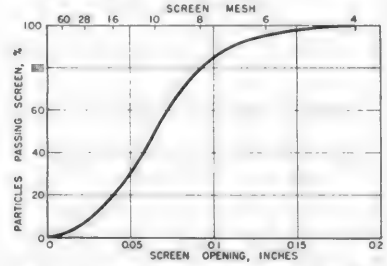


Fig. 3.—Typical sawdust particle size distribution for suspension-drying tests.

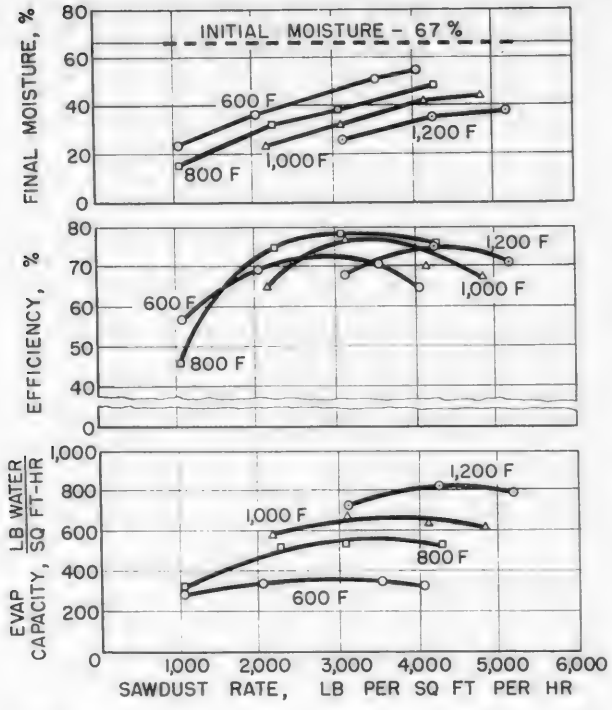


Fig. 4.—Dryer performance at 4,180 lb of air per sq ft per hr.

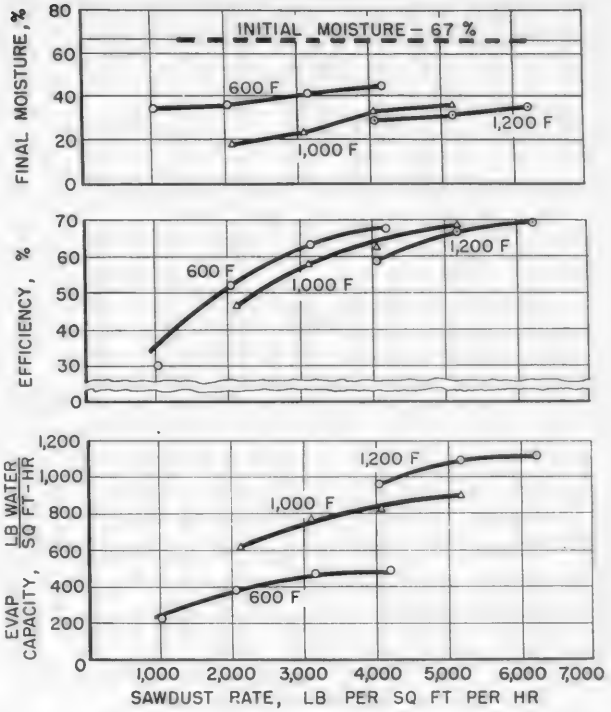


Fig. 5.—Dryer performance at 6,130 lb of air per sq ft per hr.

Test Procedure

Sawdust was dried at initial gas temperatures of 600°, 800°, 1,000° and 1,200° F., and air flow rates of 4,180 and 6,130 pounds per square foot of duct area per hour.

Three initial sawdust moisture contents were investigated—100, 67, and 33 per cent on a dry-weight basis.

Equipment: A schematic sketch of the test dryer is shown in Fig. 2. The drying duct was a pipe of 3⅝-inch diameter, 45 feet long, covered with insulation 3¼ inches thick. Air flowed from a positive-displacement blower through a propane burner, where gas temperature was controlled by regulating the propane feed rate. Wet sawdust was fed directly into the drying duct by a screw feeder. At the top of the duct, dried sawdust was separated from spent gas and evaporated moisture by a cyclone separator.

Material Studied: Sawdust dried came from a local sawmill with a band headsaw cutting mostly Douglas-fir. Typical particle-size distribution for the sawdust as received is shown in Fig. 3.

Moisture content of sawdust as received from the mill was about 67 per cent on a dry-weight basis. To obtain sawdust with 100 per cent moisture content, water was added to mill-run sawdust, while 33 per cent moisture content was reached by preliminary drying.

In addition to tests run with sawdust as received from the mill, tests were run with coarse and fine fractions. The coarse fraction was particles that would not pass a screen with ⅛-inch openings. The fine fraction was particles that passed a screen with 1/14-inch openings.

Results and Discussion

Sawdust moisture content, in this report, is expressed as a percentage of the dry weight of the sawdust.

Rates are reported in pounds per hour per square foot of duct cross-sectional area so results can be transferred for interpretation of different size dryers. A duct of 13¼-inch diameter would have an area of 1 square foot, compared to the test dryer's cross-sectional area of 1/14 square foot.

Effect of Gas Flow Rate: Dryer performance with as-received sawdust, at 4,180 lb air per sq ft per hr, is presented in Fig. 4, while performance at an air rate of 6,130 lb per sq ft per hr is given in Fig. 5. A comparison of performance shows increased efficiencies and lowered final moisture contents were obtained at the lower air rate. Tests were run at air rates higher than 6,130 lb per sq ft per hr, but lowered efficiencies resulted. Some conception of air rate-velocity comparisons can be gained by pointing out that 600° F. air flowing at 4,180 lb per sq ft per hr gives a superficial velocity of 1,870 feet per minute.

From the results, it appeared the lowest air rate that will convey the sawdust would give best performance. While the lowest air rate in the study was 4,180 lb per sq ft per hr, Parry and others (2, 3) concluded that gas rates of 1,000 to 2,000 lb per sq ft per hr are optimum for drying fine coal. Some low air rates were not tried on the test dryer because of expected plugging. Plugging was not verified by tests, however.

Effect of Gas Temperature: Indications were (Figs. 4 and 5) that final moisture content was lowered as gas temperature was raised, but maximum efficiencies did not vary greatly with initial gas temperature in the ranges tested.

The most important effect of gas temperature was on dryer capacity. When the initial gas temperature was raised from 600° F. to 1,200° F.,

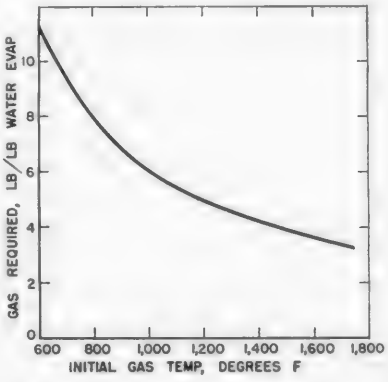


Fig. 6.—Calculated relationship between gas temperature and gas requirement at 75 per cent efficiency.

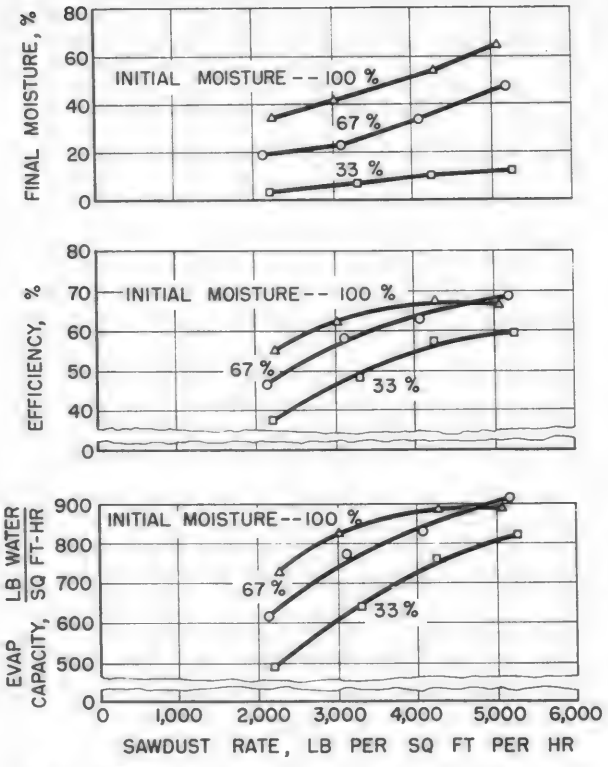


Fig. 7.—Effect of initial moisture content on dryer performance with 6,130 lb of air per sq ft per hr and 1,000° F. gas.

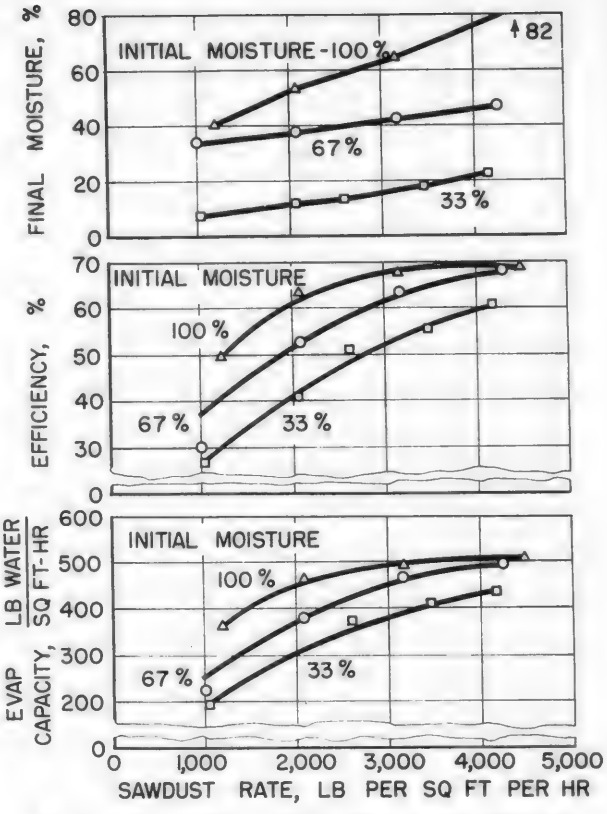


Fig. 8.—Effect of initial moisture content on dryer performance with 6,130 lb of air per sq ft per hr and 600° F. gas.

dryer capacity was more than doubled for the same air rate. Since physical size of a dryer is largely dependent on gas flow, the lowest cost drying system would have high initial gas temperatures. Gas requirements with temperature variation are shown in Fig. 6. Maximum initial temperature was 1,200° F. on the test dryer because of its construction limitations. Elevated temperatures—approaching 2,000° F. —probably could be reached by incorporating refractory materials in the dryer. Permissible maximum dryer temperatures also are dependent on use to be made of the dried product. If the product is dried for fuel or fuel briquets, some darkening of the material would not be objectionable, so high temperatures probably would be permissible. Where appearance of the product is critical, however, lower temperatures may be necessary.

Effect of Initial Moisture Content: Dryer performance is shown in Fig. 7 at an air rate of 6,130 lb per sq ft per hr, at 1,000° F. initial gas temperature, and for sawdust with 100, 67, and 33 per cent initial moisture content. Fig. 8 is similar, except that 600° F. gas instead of 1,000° F. was used. In general, it can be seen from the curves that low efficiencies were obtained with 33 per cent initial-moisture sawdust, since less free water was available for evaporation and because bound water is difficult to remove.

Advantage of dryer staging also is indicated by the curves. Increased efficiencies are obtained in reducing from high to low moisture contents, if drying is carried out in two or perhaps more steps. For example, if it is desired to dry sawdust from 67 per cent to 10 per cent moisture content under conditions given in Fig. 7, a single-stage dryer would have an efficiency of less than 45 per cent. If the sawdust were dried in two stages, however, first to 33, then to 10 per cent moisture content, efficiency of the first stage would be about 67 per cent and of the second stage about 55 per cent. Over-all efficiency, then, would be between 55 and 67 per cent, or about 60 per cent for two-stage drying compared to less than 45 per cent for single-stage drying.

Temperature variation along the drying duct for one sawdust rate from Fig. 7 is shown in Fig. 9. Duct temperatures dropped rapidly in the lower part of the duct, with small drop in the upper section. For the same conditions, nearly the same drying effect would have resulted with a duct half the length used.

Effect of Particle Size: Figs. 10 and 11 represent dryer performance for 1,000° F. and 600° F. gas with 3 particle-size ranges. It is apparent from the curves that high dryer efficiencies were obtained with small particles. High efficiency was a result of small particles that require little time to become heated and have large surface area per unit weight of sawdust.

Temperature distribution along the drying duct for a selected run from Fig. 10 is presented in Fig. 12. Here again, fast drying of small particles was indicated by a rapid drop in drying-duct temperatures.

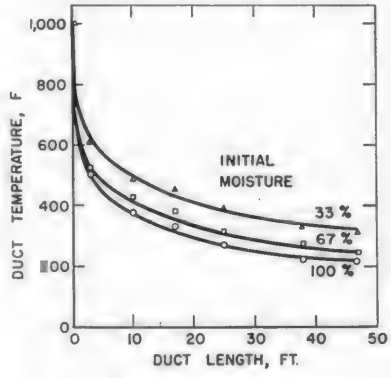


Fig. 9.—Relationship of duct temperature distribution to initial sawdust moisture content. Air rate, 6,130 lb per sq ft per hr; sawdust feed, 4,200 lb per sq ft per hr; initial gas temperature, 1,000° F.

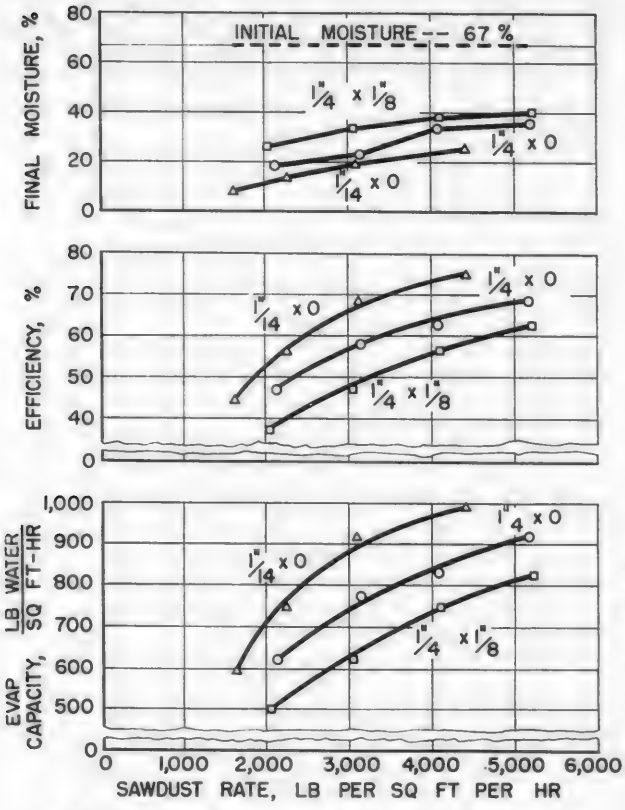


Fig. 10.—Effect of particle size on dryer performance with 6,130 lb of air per sq ft per hr and 1,000° F. gas.

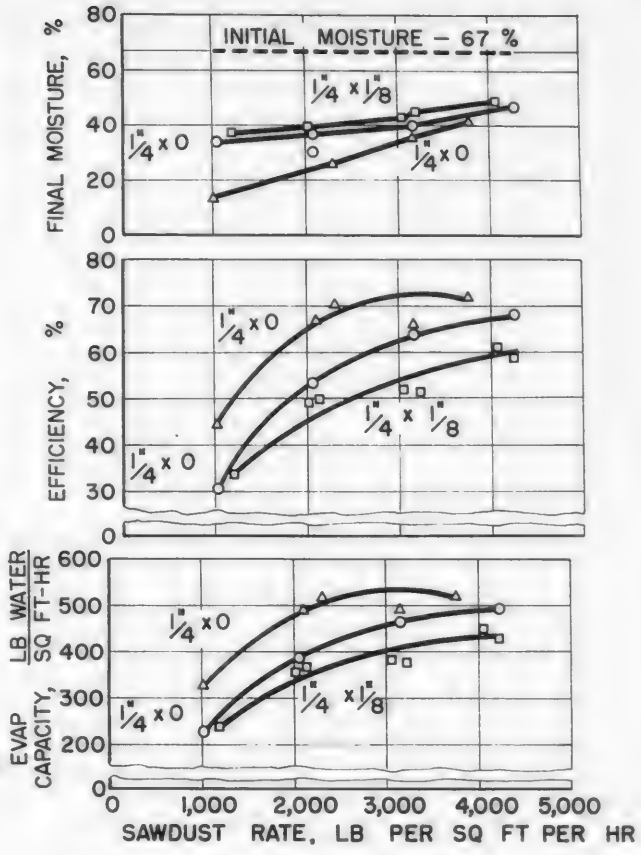


Fig. 11.—Effect of particle size on dryer performance with 6,130 lb of air per sq ft per hr and 600° F. gas.

Application

Independent Dryer: An arrangement for an independent dryer is pictured in Fig. 13. Location of the fan is shown at the cycle outlet. If the furnace were arranged to operate with a slight pressure, the fan could be placed before the furnace.

A recirculating fan is shown in the sketch. Such a fan would increase efficiency. It also would decrease oxygen content of the gas and thus reduce explosion hazard. This fan could be eliminated, however, if drying conditions resulted in low temperatures at the cyclone outlet.

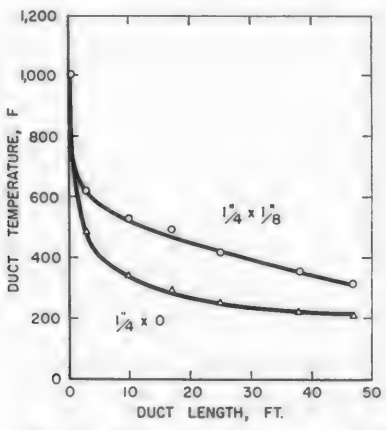


Fig. 12.—Relationship of duct temperature distribution to sawdust particle size. Air rate, 6,130 lb per sq ft per hr; sawdust rate, 4,100 lb per sq ft per hr; 67 per cent initial moisture content; 1,000° F. initial gas temperature.

Dryer Associated with Steam Plant: Steam plants frequently are present where sawdust—or like material—requires drying. Since steam plants have considerable quantities of stack gas at temperatures commonly near 600° F., this waste stack gas offers a potential source of heat for drying. It might be possible also to increase dryer capacity by extracting some hot gas directly from a boiler furnace, as shown in Fig. 13. Wood particles for a manufactured product such as wood briquets could be dried by such an arrangement. A plant at Vancouver, B. C., has a system in operation where wood particles pass through a two-stage dryer.

Another application of the dryer would be in improving fuel burned in the steam plant. By removing part of the drying process from the furnace, both efficiency and capacity of the steam plant could be increased. Tamblyn (6) reported that the Great Lakes Paper Company expected to double their steam production by installing a flash-drying system to pre-dry their bark fuel. Since particle size markedly affects performance of a flash or suspension dryer, fuel size should be noted carefully. A study of particle size may show that the fuel would have to be hogged or reduced in size before a suspension dryer would be profitable.

To point out heat potential in stack gas from a steam plant, consider a wood-fueled installation with a capacity of 50,000 pounds steam per hour, with stack gas at 600° F. This plant

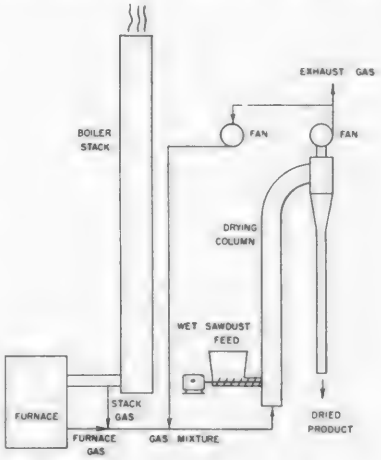


Fig. 13.—Particle drying by stack gas or furnace gas, with recirculation possible.

would emit about 95,000 pounds of stack gas an hour. Potential heat of the gas, above 200° F., would be about 10 million Btu an hour, or nearly 12 per cent of the total heat of fuel burned. Drying capacity from this heat would be about 3 tons of water an hour, or about 7 units of sawdust an hour could be dried from 65 per cent down to 25 per cent moisture content. If heat of the stack gas were used to dry fuel for the steam plant, the same quantity of fuel would produce about 17 per cent more steam. Heat potential from a boiler stack is, indeed, significant.

Conclusions

Suspension drying is a simple method for drying sawdust in which high efficiencies can be obtained. Maximum efficiencies of about 75 per cent were obtained with the lowest air rate studied, 4,180 lb per sq ft per hr. Dryer efficiency and capacity decreased when particle size increased, thus limiting suspension drying to material of small size. Combining a suspension dryer with a steam plant is a way in which wasted stack gas could be put to effective use.

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Impact Force-Deflection Diagrams for the FPL Toughness Test[1]

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A method is given for producing force-deflection diagrams of specimens tested in the FPL Toughness Testing Machine. The record is produced on an oscilloscope from the output of force and deflection transducers. Results indicate the electrical measuring system is an improvement, but the peculiarities of the machine make the results questionable.

IN MOST CASES where wood is used as a structural material, the problem of impact loading must be considered. Information presently available indicates that the relative behavior of wood is different under impact as compared to static loading, yet detailed information is lacking. Until more is known of this behavior, truly efficient design of wood structures is impossible.

Impact has been a difficult problem to study because of the inability to measure such transient phenomena. With recent developments in instrumentation, however, it is theoretically possible to make such measurements quite accurately.

As far back as the early 19th century, it was recognized that the rate of loading had an effect on the elastic properties of wood. These conclusions were drawn from studies of dynamic properties. In the early part of the 20th century, investigators began to study the problem in more detail. A report by Tiemann (10)[2] related the speed of testing to strength. This relationship showed that, as the loading rate increased, the load-carrying capacity of the specimen also increased. Later, Elmendorf (3), in a study of the problem of impact testing of wood, showed that the modulus of elasticity for impact-loaded specimens is about 25 per cent higher than that determined by static methods.

The relationship of strength properties and loading rates in the range between static and impact loading was investigated by the Forest Products Laboratory at Madison, Wis. (2, 8, 11). With the exception of the modulus of elasticity in bending, the strength properties were found to increase with increased loading rates. Equations were calculated that related these properties to the loading rates.

The effect of rapidly applied loads has been studied at the State University of New York College of Forestry by Kitazawa (6), who used a vibration technique. He found that the modulus of elasticity of wood beams subjected to flexural vibration at the

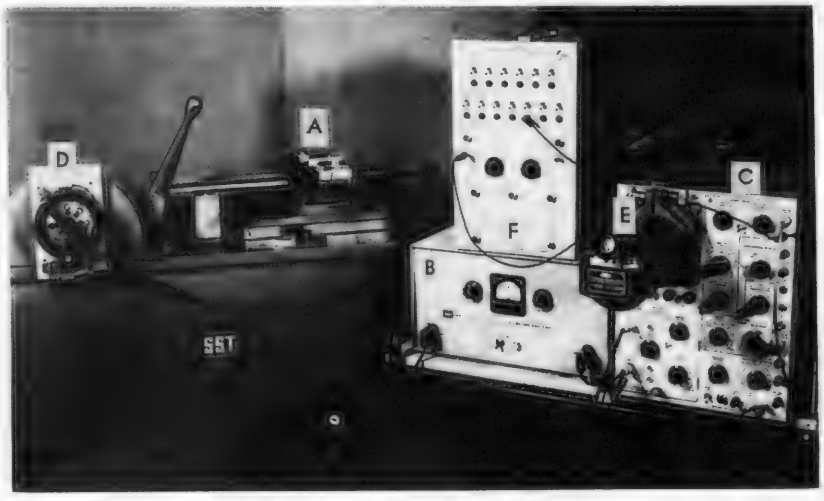

Fig. 1.—Arrangement of equipment, showing the force transducers (A), D.C. amplifier (B), oscilloscope (C), deflection transducer (D), oscilloscope camera (E), and time mark generator (F).

[1] A 1956 Wood Award Entry.
[2] Numbers in parentheses refer to Literature Cited at the end of this report.

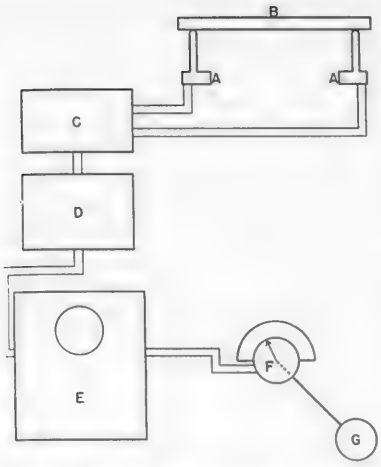

Fig. 2.—Block diagram of the equipment used, showing the force transducers (A), test specimen (B), wheatsone bridge (C), D.C. amplifier (D), oscilloscope (E), deflection transducer (F), and pendulum (G).

fundamental resonant frequency was about 10 per cent higher than the statically determined value.

Zerbe (12) used a Hatt-Turner Impact Testing Machine and several methods of calculation, and found the modulus of elasticity to be higher for impact bending than for static tests. The magnitude of the difference is somewhat dependent on the method of calculation. His conclusions are consistent with the general trend in these investigations.

A pendulum-type impact testing machine is potentially one of the most usable means for evaluating impact strength in wood. The test yields only a single value of total absorbed energy, however. This limited information cannot give much of an insight to the relationships that need investigation. The Forest Products Laboratory Toughness Testing Machine (4) was used in this study.

The primary problem was to modify the testing machine in such a way that force-deflection curves could be produced. Previously, two different types of modification have been used on impact machines. Kollmann (7) reports that in France the specimen supports were replaced with a modified Brinell Hardness Indicator, which was used to indicate the maximum load applied. This method has definite limitations, since only the maximum load is recorded. Kollmann replaced the Brinell Hardness Indicator with a piezoelectric crystal as a force transducer, and recorded the force signal versus time by means of a cathode ray oscillograph and photographic paper.

Methods and Materials

The system used in this study was an extension of Kollmann's method; electric resistance strain gages were used for the force transducers, and a linear potentiometer was used for deflection measurements. The signals from these instruments were simultaneously displayed on a cathode-ray oscilloscope screen as a force-deflection diagram.

To measure the force acting during a test, the beam supports of a standard toughness machine were replaced by force-measuring transducers, which are shown in Fig. 1(A) and Fig. 3. The force signal produced was amplified with a Kaylab D.C. Decade Amplifier, Model 103 (B), and then fed into the Y axis of a type 535 Tektronix cathode-ray oscilloscope (C). For deflection measurements, a linear, circular-motion potentiometer (D) was connected to the angle indicator of the toughness testing machine. The signal from this instrument was fed into the oscilloscope to produce trace deflections in the X direction.

The combined trace on the oscilloscope screen was recorded by a 35 mm. camera (E). A triggering circuit was necessary to start the oscilloscope trace at the proper time in relation to the phenomena being measured. For this purpose, a microswitch was tripped by the potentiometer wiper just prior to application of the load to the beam. In addition, time marks at 0.010-second intervals were superimposed on the trace from impulses produced by a Tektronix Time Mark Generator, Type 180 (F).

Estimates of the magnitude of forces and deflections in the toughness test were necessary as a basis for the design of the transducer elements. A series of four high-speed motion picture records was made on air-dry sugar maple (*Acer saccharum* Marsh) with a Wollensak Fastax High-Speed 8 mm. camera. Deflections were estimated from the pictures, and total energy consumed was taken from machine readings. From these data, and assuming failure occurred at the end of the elastic range, an estimate was made that the maximum load was in the order of 2000 pounds.

The Force Transducer: The design of the indicating portion of the force transducer was determined from the assumption that a safe load estimate would be 2000 pounds per support; that a maximum strain of 0.0005 inch per inch would produce an adequate signal; and the modulus of elasticity for aluminum alloy is 10.3×10^6 psi. From these data, calculations showed a required 0.389 square inch of cross section. The transducers were machined to a sectional area of 0.387 square inch.

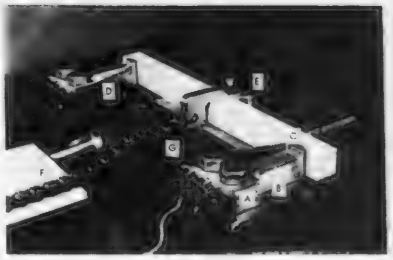

Fig. 3.—Detail of the force transducers. Transducer (A), strain gage (B), half-round bearing piece (C), shield (D), tup and yoke (E), chain (F), and bed plate of the testing machine (G).

The force transducers (A) shown in Fig. 3 were made of 75ST6 wrought aluminum alloy plate 0.75 inch in thickness. Two pieces were cut from this stock in the form of a "T" and milled to shape. The cross bar of this "T" was bored for two standard ½ by 13 machine bolts for mounting the transducer in the support pin holes already drilled in the base block. The vertical bar of the "T" acted as a support for the beam, and was the active part of the transducer. One Baldwin SR-4, CD-7 electric resistance strain gage (B) was mounted on each side of this active portion. These strain gages had a gage factor of 3.21 ± 2 per cent and a resistance of 500 ± 3 ohms.

The end of the transducer supporting the beam was furnished with a half-round steel bearing piece (C) with a radius of 0.312 inch, which corresponded to the radius of the support pins normally used on this machine.

A metal shield (D) was placed on the inside faces of the assembly so that the ends of the beam would not scrape against the gages as the beam was pulled between the supports. Also, the shield was turned under the anchored end of the transducers to provide a firm attachment for the shield and act as a shim. In this way there was no possibility of frictional forces between the transducer and base block.

A normal Wheatsone bridge circuit was used to measure the output. The pair of gages on each transducer was connected in series so that only the compressive component of force was measured; each of these formed one active arm of the circuit. Four dummy gages mounted on aluminum plate formed the inactive temperature-compensating arms of the bridge (9). This circuit was powered by a 45-volt dry-cell battery.

Calibration tests were made by loading both transducers simultaneously in a universal testing machine. Fig. 4 is the calibration curve produced.

Deflection Transducer: The deflection-measuring system shown in

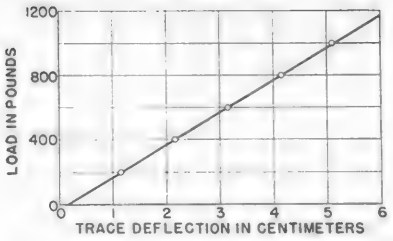

Fig. 4.—Calibration curve for the force transducers, produced from static load and oscilloscope trace deflection.

Fig. 1 (D) was constructed from a linear, circular-motion potentiometer with a total resistance of 10,000 ohms. The potentiometer was driven by a 2½ to 1 geared connection to the indicating axis of the toughness machine. By this means, a single direction of sweep was produced. The circuit was powered by a 45-volt battery, and output signal was fed directly to the oscilloscope without amplification. In this arrangement, measurements were actually being made of the pendulum. It was assumed that the tup and pendulum moved together, except for differences caused by stretching of the chain. To determine the amount of deformation, the chain was loaded in static tension in a 5000-pound, universal testing machine. The chain calibration curve produced is shown in Fig. 5.

Experimental Procedure: The testing procedure was designed to evaluate as well as possible the performance of the force and deflection transducers under actual testing conditions. The absence of experimental data for such conditions precluded the possibility of a direct comparison of results. For this reason, an "order of magnitude" comparison was all that could be accomplished. To eliminate as many variables as possible, three different tests were made on each of 30 specimens of American beech *(Fagus grandifolia* Ehrh.). Each test was made to determine Young's modulus only. The specimens were machined to size for ASTM standard toughness specimens —0.79 in. by 0.79 in. by 11 in. (1).

The material was originally green, and was maintained in this condition by wrapping each specimen in Saran Wrap and storing the wrapped specimens in a refrigerator between tests. They were brought out only long enough for them to come to room temperature prior to testing.

The test procedure consisted of three separate steps. Initially, each beam was tested dynamically by the method of Kitazawa (6). The next step was to carry out a modified static-bending test on a standard universal machine to determine Young's modulus. The specimens, with a span of 9.45 inches, were center loaded as simple beams at a rate of 0.05 inch per minute. The maximum loads applied were kept below 75 pounds, which was estimated to be less than two-thirds of the load at proportional limit. Force-deflection curves were plotted for each specimen.

Finally, toughness tests were made on all pieces. The records of the toughness tests consisted of photographs of the oscilloscope traces for each beam, plus data on the initial and final angles of the pendulum, and oscilloscope equivalents for force and deflection. After the final test in the series, moisture content and specific gravity determinations were made for each beam, and the grain angle was measured on two adjacent faces as close to the break as possible.

Results

The computation of results was similar to standard processing methods employed for static tests. For the static and toughness tests, the force-deflection curves were used to determine the elastic line. This made possible the calculation of a modulus of elasticity, E, by means of the standard equation from the mechanics for center-loaded simple beams.

Since the elastic portion of the curves for the impact tests was irregular (Fig. 6), the elastic line was established by fitting a straight line to the curve by eye. The elastic line thus established was known to be in error due to chain deformation, which caused greater recorded deflections than were produced in the beam. The elastic portion of the curves occurred almost entirely in the range of nonlinear chain deformation below 300 pounds (see Fig. 5). To obtain a true line, each force-deflection curve would have had to be replotted with a chain deformation correction for each plotted point. Such a procedure would be further complicated by the irregularities in the original curve, which would leave the results still questionable. It was therefore decided to obtain the best possible estimate of E by applying a correction factor for deflection determined from the linear portion of the chain calibration curve.

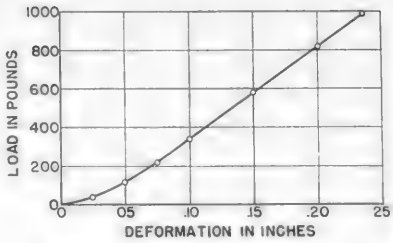

Fig. 5.—Calibration curve for 33.5 inch length of No. 41 Morse Roller Chain used on the toughness machine.

In the dynamic tests, the method of Kitazawa (6) was followed. To determine E values the following equation was used:

$$E = 0.9468 \quad \frac{f_r^2 \, L^4 \, \rho}{h^2}$$

Where E is the modulus of elasticity, f_r is the resonant frequency, L is the beam length, ρ is the density, and h is the beam depth.

Analysis and Discussion

Form of Curves Produced: The general form of the impact force-deflection curves was similar to those obtained in static tests. The two parts of Fig. 6 are enlargements of the oscilloscope trace photographs of impact tests made on two specimens. The initial part shows a very steep rise and a tendency toward linearity. A truly straight line in this region may have been obscured by the irregularities that appear to be periodic in nature. It is believed that vibrations in the chain account for this. High-speed motion pictures taken of the chain action during test showed vibrations occurring during this portion of the loading cycle.

The estimated period of vibration of the chain closely corresponds to the time distance between the periodic peaks displayed by the oscilloscope trace. This estimation was made by measuring the distance on the film between frames that showed peaks in the chain vibration. Then, since the speed at which the film was running through the camera was known, the period of chain oscillations was calculated.

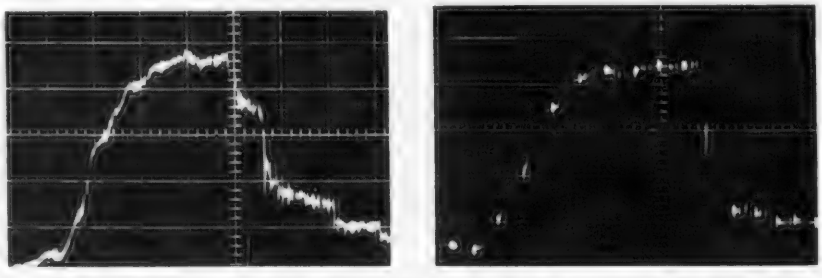

Fig. 6.—Enlargements of the photographic records of the toughness tests on specimens Nos. 11 (left) and 13 (right). The trace moved from left to right. The grid is that of the oscilloscope graticule, with one cm spacing between lines. On the force axis (y), one cm equals 100 pounds of load; on the deflection axis (x), one cm equals 0.2 inch of uncorrected deflection. The camera setting was f2.8 and bulb. Kodak plus X roll film was used.

Another source of error that influences the deflection as measured at the pendulum axis is the elastic deformation of the chain under load. The recorded deflections are the sum of true bending deflection of the beam plus chain stretch and effects of chain oscillation. To calculate true strength properties from the curve, corrections are necessary to eliminate the chain error. An added complication arises from non-linear chain deformation at the low load levels obtained in these tests (Fig. 5). The cause of this peculiarity may be flow of the lubricant at the pins connecting each link of the chain.

The curves show a definite peak that indicates maximum load. This occurs either at or just prior to the initial tension failure. The failures are recorded as an almost instantaneous reduction in load, followed by a stepwise reduction in the curve for tough specimens after the initial break. These successive decrements indicate ruptures occurring in sequence at different depths in the beam in a manner similar to failure in static bending. Finally, the curve smooths out into a long tail that in most cases runs beyond the boundary of the photograph.

Comparison of Results: The mean values of Young's modulus for the 30 specimens in the three types of test were: 1) static, 1.151×10^6 psi; 2) dynamic, 1.424×10^6 psi; and 3) toughness, 1.040×10^6 psi. The increase of the dynamic value over the static follows the trend found by Kitazawa (6) and Zerbe (12). The value found from the toughness test is evidently of the same order of magnitude as the other two, which suggests that the fundamental approach to the problem is correct.

Since previous work has shown that an increase in loading rate results in increased E values, the opposite relationship found between the static and toughness values obtained in this study is probably indicative of a systematic error due to the measuring devices. The knowledge gained by studying the behavior of the chain used with the toughness machine indicates that this is the most probable source of error.

Both the non-linearity of the chain deformation and vibrations in the chain will cause error in the deflection measurements. Such errors would be especially serious in the determination of the elastic line, since the total deflection over this range is quite small. Thus, even a small error in deflection measurement could be a significant percentage of the total deflection in the elastic region of the curve.

A comparison of the standard deviation for the data obtained in each type of test indicates that the toughness values were quite consistent. The standard deviations were: 1) static, $\pm$ 0.214 $\times$ 10^6 psi; 2) dynamic, $\pm$ 0.264 $\times$ 10^6 psi; 3) toughness, $\pm$ 0.166 $\times$ 10^6 psi. The coefficient of variation in each case was: 1) static, 18.6 per cent; 2) dynamic, 18.5 per cent; 3) toughness, 16.0 per cent. This compares with a coefficient of variation for the static modulus of elasticity of 22 per cent given in the Wood Handbook (5).

The form of the oscilloscope trace photographs (Fig. 6) of the toughness test indicates the possibility of obtaining information on the modulus of rupture and energy utilized during the test. For the modulus of rupture, the maximum load applied to the specimen can easily be found from the oscilloscope diagram. Then the value of the modulus can be calculated by the standard static equation. Investigations of the behavior of the modulus of rupture under impact conditions would be of interest, since Liska (8) has shown that this modulus does increase with increased loading rates.

Since the force-deflection diagram has force as one axis and distance as the other, the product of the two has the units of energy. Thus, the area under a force-deflection curve represents the energy required to bend the specimen. The measurement of this area can easily be accomplished with a polar planimeter, and when accurate transducers are used to produce the diagram, a measurement of this energy may be obtained.

Machines presently in use measure this energy requirement by mechanical means, and produce results of questionable accuracy. This is especially true in the case of the FPL Toughness Testing Machine, since energy losses are known to occur due to chain deformation and vibration. Thus, a force-deflection curve, derived from a test, potentially can give a more accurate picture of the energy utilized for beam deformation.

Conclusions

The results of this study indicate that the fundamental method of using electrical transducers and an oscilloscope for obtaining force-deflection diagrams of an impact test is correct. However, refinements in both the force and deflection transducers are necessary to obtain accurate curves.

Probably the most serious source of error is in the deflection-measuring system, which indicates beam deflection plus non-linear chain stretch and chain oscillation as well. Much of this error could be eliminated by measuring the deflection at the center of the beam instead of at the pendulum axis. This would necessitate complete redesign of the transducer, but would provide a system that would give a better picture of beam deformation during the test. It probably would not eliminate the inherent effect from the chain oscillation, however.

As stated earlier, the force transducers were designed for loads up to 2000 pounds. For the material used, maximum loads between 400 and 500 pounds were obtained, which means that the transducers were operating in a small part of their total range. It was therefore necessary to amplify the signal considerably. For testing species of medium and low strength, it would be desirable to reduce this maximum design load and thereby increase the sensitivity. Redesign of the force transducers would be necessary to accomplish this.

These suggested modifications in the measuring equipment will still leave unsolved the problem of the chain effects. Proper testing requires that either constant rates of loading or deflection are maintained throughout the test. In the case of the toughness testing machine, one effect of the chain is to superimpose an oscillating load upon the constantly increasing load produced by the pendulum. These loading variations are bound to cause variations in the deflection rate, and are inherent in the design of the machine. Since rupture can occur at any point in the cycle of the oscillatory component, this factor cannot be adequately assessed.

The other effect concerns the energy stored in the chain when it is loaded. It is clear that in the case of brash wood, which fails suddenly and completely, the energy in the chain will do little, if any, work in breaking the specimen. The machine will indicate that this energy has been utilized in breaking the specimen, however. Thus it is doubtful that the machine can present a true and consistent picture of the work to rupture, which is the meaning of the toughness test.

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Simplified Tension Tests for Wood

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A modified tension test specimen that has certain advantages over the standard specimen is presented. It allows any reasonable width up to one inch to be tested, and thus will be useful especially in wood-quality and end-jointing studies where the standard ASTM specimen might be impractical.

STRAIGHT-GRAINED WOOD is extremely strong in tension parallel to the grain. Its tendency to shear out at fastenings, however, makes wood difficult to use to full advantage as a tensile member in engineering designs. Both the difficulty of using wood as a tensile member and the difficulty of testing wood in tension have discouraged extensive research on its tensile strength. Increased use of deep laminated beams in which the bottom layers are highly stressed in tension has stimulated interest in the tensile strength of various glued end joints as well as that of the wood itself.

Although the present standard ASTM tension specimen (1)[1] is a marked improvement over previous designs, it is still fairly difficult to fabricate (2), and is wasteful of experimental material. A piece of wood one inch square and 18 inches long is needed to test a cross sectional area of 0.070 square inch. The necessity of shaping the ASTM specimens from all four sides requires extra time, complicates the jig setup, dictates a test width that is too narrow for many end-jointing studies, and contains too few annual rings in fast grown stock. It is hoped that the present modification will expand the field of utility of the tension test.

Design of New Specimen

If a tensile specimen with planes of weakness in the springwood has easement curves shaped in from the tangential faces, the wood usually shears in the springwood, which destroys the curve. The frequency with which this happens casts considerable doubt as to the desirability of shaping an easement curve in from the tangential face. In view of this fact, a specimen was designed that has easement curves shaped in on only the two radial faces (Fig. 1). This design permits a specimen of any reasonable width that the specimen holder will take. Freedom in the choice of specimen width allows precise groups of annual rings to be tested in wood-quality studies. This freedom in choice of widths also allows various end joints (Fig. 2) to be tested, with the specimen width coinciding with the standard dressed thickness of the lumber for which they were designed. In such studies, the unjointed controls are tested in the same dimension as the jointed specimens so that strength ratios can be calculated without the possibility of a form-factor difference between joints and controls.

In addition to being shaped inward on only two sides of the specimen instead of four, the easement curves of the modified specimen are elliptical rather than circular. A properly oriented elliptical curve is very efficient in reducing stress concentrations, since a very large radius of curvature can be placed at the most critical region without the necessity of continuing such a large radius of curvature into less critical regions. The simplified specimen, because of its thinner center section, would need to be longer than the ASTM specimen if a circular arc were used for the easement curve. By use of an elliptical curve, however, plus other minor alterations, the test specimen can be made three inches shorter than the ASTM specimen. An ellipse with the following equation fits the specimen and has a maximum radius of curvature of 16 inches:

$$\frac{x^2}{6.065} + \frac{y^2}{.1434} = 1$$

The use of the 15-inch rather than the 18-inch specimen may provide some saving of test material. More important, perhaps, for 20-inch material, the 15-inch specimen can be taken from such a position that a minor defect that may be present does not fall in the critical central region of the test specimen.

Although the modified specimen can be shaped from solid wood, the test material can be put to more efficient use by ripping it into thin slats onto

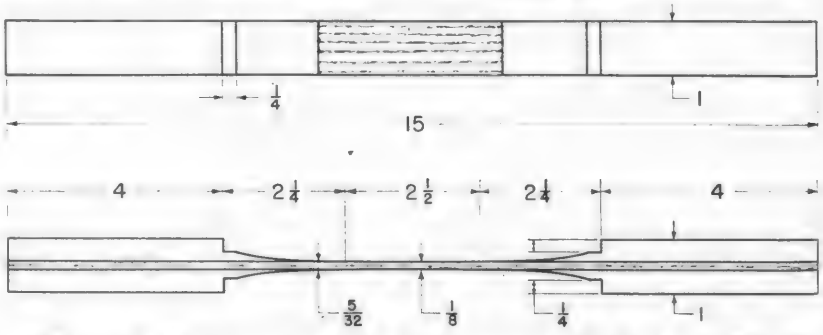

Fig. 1.—Modified specimen for testing wood in tension parallel to the grain. The elliptical easement curves are shaped in on only two faces. Note the small amount of test material required when glued-on hardwood grips are employed.

[1] Numbers in parentheses refer to Literature Cited at the end of this report.

The Author: D. B. Richards attended Park College, Mo., and received a BS degree in Forestry from Colorado A&M, and MS and PhD degrees from the New York College of Forestry, Syracuse. He was an instructor in wood utilization at Syracuse, and a wood technologist and lacquer chemist before joining the Auburn faculty in 1951.

Fig. 2.—Typical tension specimens. The four pairs from left to right are finger joints in southern pine, southern pine controls, simple scarf joints in white ash, and white ash controls.

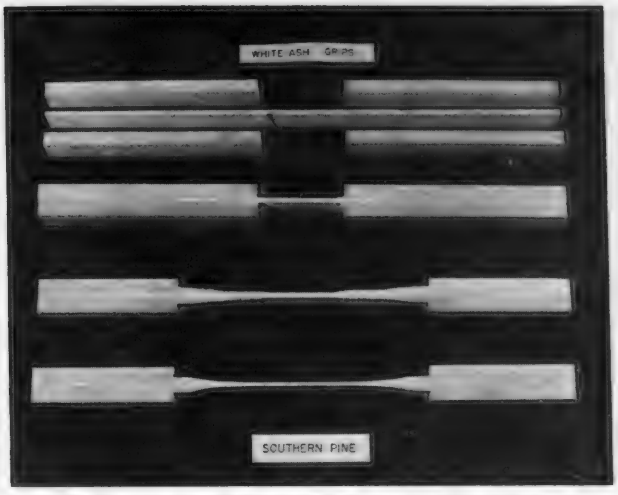

Fig. 3.—Steps in the fabrication of a modified tension specimen, showing the thin test slat and hardwood grips, the grips glued to the test slat, the specimen after shoulder notching and rough bandsawing of the grips, and the finished specimen with the elliptical easement curve shaped smoothly through the hardwood grips into the central test slat.

which hardwood grips are glued (Fig. 3). Beech, hard elm, oak, and white ash have been used successfully for grips; other dense hardwoods could be used as well. While the grips need not be selected quite as carefully as the tension specimen itself, they should be of good quality, since excessive cross grain may cause them to shear out during the test.

If dry wood is used, one of the quick-setting polyvinyl glues speeds up the gluing of the grips. An additional advantage of such a glue appears when a grip fails without breaking the tension specimen. The broken grips can be removed by soaking the ends briefly in hot water. After the specimen is dried and dressed lightly, new grips can be glued on, and the whole specimen can be reshaped slightly thinner for retesting.

Fabrication of the Specimens

Obtaining straight-grained material is one of the major problems of any tension testing program. The following techniques have proven successful in woods free of interlocked grain or excessive cross grain.

1. Flat-sawn boards of 5/4 or 6/4 inch rough stock are cross cut into pieces about 20 inches long.

2. Any slight diagonal grain is carefully removed by making wedge-shaped cuts on a jointer.

3. By careful mapping of seasoning checks or wood structures or by use of a grain-marking device, the general orientation of any spiral grain is drawn as a grain line on the flat-sawn surface of the board. (The grain orientation can also be established by splitting the board down the center.)

4. Test slats about 3/16 inch thick are ripped parallel to the grain line. If there is very much spiral grain, only the flat-sawn region of the board will yield straight-grained slats, since in the bastard-sawn region a component of the spiral grain will be sloping through the thickness of the board and will not be removed by this ripping technique.

Once the straight-grained slats have been prepared, they are dressed on both sides to a uniform final thickness of 5/32 inch. If the slats have been prepared about 20 inches long, the 15-inch test specimen can be cut from the slat in such a manner as to avoid placing any minor grain irregularity in the central five inches. The end trimmings can be used as specific gravity samples, or the whole slat can be brought to equilibrium at a constant relative humidity, and the specific gravity can be calculated on the basis of the dimensions and weight of the specimen at the known moisture conditions.

Hardwood grips of appropriate thickness are glued to the test slats and sawed and shaped to final pattern (Figs. 1, 3). The cutting of the notches that form the load-bearing surfaces during the test should be done accurately. A ball socket or other universal joint on the specimen holder will not automatically deliver a straight pull on an unbalanced or poorly fabricated specimen. Special care must be taken to assure the accuracy of these bearing shoulders. If this is done, it will be found that an accurately aligned testing machine will yield satisfactory tension data without using universal joints on the specimen holders.

The easement curve, which is shaped into the specimen from the two opposite sides, is elliptical (Fig. 1). This curve can be drawn by attaching a pencil to the end of a thin wire, and wrapping the wire around the evolute[2] of the ellipse (Fig. 4). The curve to be cut in the jig (Fig. 5) can be traced in a similar manner from the evolute by shortening the wire the amount by which the shaper knives overhang the shaper collar, and tracing a second involute from the evolute curve. The second involute curve is band sawed in the jig and then adjusted to final form by sanding or scraping until the proper resultant curve in the specimen is obtained. The shaper should be equipped with a ball-bearing collar (Fig. 5) against which the jig is placed during shaping. This prevents excessive wear and burning of the

[2] The equation of this evolute is best expressed in parametric form:

$$\alpha = (a^2 - b^2)\cos^3\phi = 2.403\cos^3\phi$$

$$\beta = \frac{a}{b}(b^2 - a^2)\sin^3\phi = -15.62\sin^3\phi$$

Where α is the x coordinate and β the y coordinate of a point on the evolute.

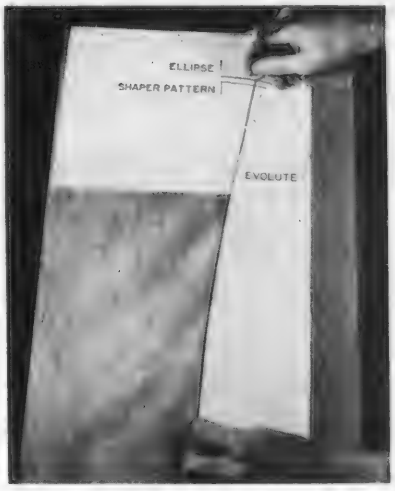

Fig. 4.—Use of an evolute curve for drawing an elliptical curve or its parallel shaper pattern.

Fig. 5.—Tension specimen in jig, ready for shaping. Note the ball-bearing collar on the shaper.

wooden jig, and allows it to perform satisfactorily even after considerable usage.

The shaper knives can be adjusted for depth of cut until the proper thickness is produced in the center section of the specimen. For woods with high tensile strength, the center section should be reduced to about 1/10 inch. In woods of moderate strength it may be left 1/8 inch thick.

In addition to the advantage of requiring only two shaping operations, the modified specimen furnishes straight, firm, bearing surfaces to which the jig can clamp from above and below. This imparts enough rigidity to the specimen that no special backing blocks are needed. Each specimen can be shaped on one side, then turned over and shaped on the other side without inserting any backing blocks or shaped hold-downs in the jig between operations.

Testing Procedure

The least dimension of this type specimen must be measured to 0.001 inch to obtain accuracy of 1 per cent. This measurement can be made conveniently by means of a dial gauge (Fig. 6) with a rounded tip of fairly large radius for both the upper and lower bearing. With such a gauge, it is a simple matter to slide the specimen lengthwise until the minimum section is located, and then slide the specimen back and forth to read the average thickness at the region of minimum section. The dial gauge should have a full inch of travel so that the width of the specimen at the minimum section can also be measured to 0.001 inch. After being measured, the specimen is placed in standard ASTM grips (Fig. 7) and tested to destruction. If only maximum tensile strength is desired, the test can be run at a somewhat faster rate of loading than standard, and only the maximum load recorded. The results reported here were obtained by testing at a loading rate of 0.08 inch per minute.

Fig. 6.—Dial gauge used in measuring test specimens to 0.001 inch. The lower bearing is a rounded button that matches the upper one. Each has a diameter of 1/2 inch and a radius of curvature of 7/16 inch.

Discussion of Typical Results

The tensile strength values obtained with the new specimen (Table 1) are high in comparison with some values from the literature, but are similar in magnitude to those of two reported studies (4, 5).

Comparison on the basis of somewhat similar specific gravity reveals an interesting relationship between tensile strength values of the modified specimen (Table 1) and values in these two studies (4, 5). There are marked similarities between the 21,263 psi value of the southern pine modified specimen and the 19,900 psi tensile strength reported (4, 5) for Douglas-fir, and between the 26,335 psi value of the white ash modified specimen and the 26,700 psi tensile strength reported for yellow birch (4, 5). It is felt that these values approach the true tensile strength of the wood in each case.

Published reports that show tensile strength from 9,000 to 15,000 psi for dense softwoods and from 12,000 to 18,000 psi for dense hardwoods are open to question in the light of the present information. It is possible that such relatively low strength values are the result of stress concentration in the specimen or of undetected cross grain.

The present study used a faster rate of loading and somewhat drier specimens than most other studies. Because the exact effect of moisture content and rate of loading on tensile strength has not been demonstrated, no corrections were applied for variations in these factors. If the need for such corrections is ever clearly indicated, they should, of course, be applied. It seems doubtful, however, that differences in excess of 10 to 15 per cent can be attributed to these factors.

Fig. 7.—Modified tension specimen loaded in standard ASTM grips ready for testing.

The modified specimen, like other tensile specimens, yielded considerable variation between individual test pieces. The coefficients of variation ranged from 17 to 19.6 per cent (Table 1), and are of the same order of magnitude as those of Plate and Raese (5), which ranged from 13 to 25 per cent. Markwardt and Youngquist (4) report a coefficient of variation of 10.4 per cent for the ASTM standard specimen in Sitka spruce. This latter value is for specimens from only one plank, however, and would normally be lower than a coefficient based on specimens taken from several different boards, as were the coefficients reported in Table 1.

In the derivation of basic stresses and working stresses for wood, standard practice is to use modulus of rupture in place of tensile strength. The conservative nature of this practice is substantiated by the high tensile strengths revealed by the present study. These strength values for loblolly pine and white ash are, respectively, 166 and 171 per cent of the published values of modulus of rupture (3) for these species in the air-dry condition.

Summary

A modified form of the ASTM tension specimen is presented. In comparison with the standard specimen, the modified specimen requires less experimental material, is easier to fabricate, and allows testing at various widths up

Table 1.—TYPICAL TENSILE STRENGTH VALUES OBTAINED WITH THE MODIFIED TENSION SPECIMEN

Species	Number of specimens	Average specific gravity*	Average moisture content, per cent	Average tensile strength, psi	Coefficient of variation, per cent
Southern pine	115	0.54	8.1	21,263	18.2
White ash	84	0.64	7.9	26,335	19.6
Red oak	13	0.70	6.2	24,346	17.0

*Specific gravity based on oven-dry weight and oven-dry volume.

:o one inch. The specimen yields very high strength values that probably approach the true tensile strength of wood.

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Strength Properties of Tension Wood and Typical Wood in a Leaning Eastern Cottonwood Tree[1]

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The paper presents an analysis of the shear and tension properties perpendicular to the grain of tension wood and typical wood of eastern cottonwood (*Populus deltoides* Bartr.). The cross-lap specimen is compared with the block-shear specimen, and three resin glues are compared as related to the type of glue test specimen.

COTTONWOOD IS ONE of the Midwest's most important species, not only because it grows rapidly but also because it is capable of growing on land unsuitable for agriculture because of flooding or poor drainage. With increasing need for lumber and veneer, cottonwood will no doubt be in greater demand.

In a recent survey made in the southeastern one-quarter of Iowa, 17 million board feet of cottonwood was used annually (1)[3]. Of the industrial users contacted in this survey, 85 per cent indicated that cottonwood presented some fabrication difficulties. Many of these difficulties are associated with the presence of tension wood.

Cottonwood is a fast growing species that is extremely sensitive to light. As the leaves and then the branches stretch forth in response to light, the boles of the trees eventually grow in a leaning position. As a result, leaning trees are frequently in the majority in cottonwood stands.

Tension wood is an abnormal tissue that develops on the upper sides of leaning hardwood trees, and is extremely prevalent in cottonwood. It is characterized by the presence of gelatinous fibers. The properties of tension wood of most interest to industrial users are as follows:

1. The release of growth stresses during sawing may be sufficient to pinch the saw and cause it to stall or overheat.

2. Freshly sawn tension wood lumber often has a fuzzy surface because of projecting fibers. This is also noted on planed and turned material and on rotary and sliced veneer.

3. Lumber or veneer containing tension wood shrinks excessively along the grain. This results in bowing, twisting, and crooking in lumber and buckling in veneer. In extreme cases, cross breaks may develop.

Comparatively little is known of the behavior of tension wood in shear and tension perpendicular to the grain. It is chiefly in these properties that glue joints are stressed, and then more often in tension than in shear. Data on these properties may prove of value to industries using cottonwood in glued products. The objective of this experiment was to compare the glue-joint strength as evaluated by the cross-lap and block-shear test specimens of tension wood from the upper side, and apparently typical wood from the lower side, of a cottonwood tree leaning 7 degrees from the vertical. Of the material from the upper side of the tree, only that with projecting fibers was classified as tension wood, because it is this characteristic that is most often used to differentiate typical and tension wood. The wood from the lower side of the tree appeared microscopically (2) and macroscopically to resemble that from other cottonwood trees believed to have typical wood structure.

Procedure

General: The standard block-shear test specimen, ASTM 905–49 (3), and a newer specimen, the cross-lap, ASTM D1344–54T (4), were used to evaluate the wood in shear parallel to the grain and in tension perpendicular to the grain (Fig. 1). Three room-temperature-setting resin glues were used to evaluate the bonding characteristics of the wood and the specimen types. Data were recorded as to quality of gluing surfaces presented by planed specimens of typical wood and tension

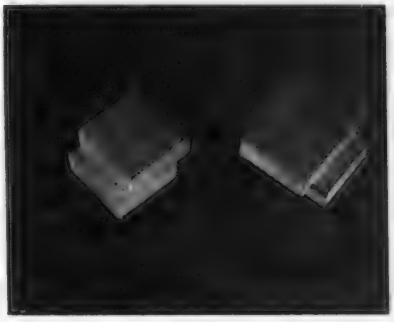

Fig. 1.—Left, the block-shear test specimen; Right, the cross-lap test specimen.

[1] Journal Paper No. J-3192 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1330. This work was conducted at Iowa State College in partial fulfillment of the requirements for the degree of Master of Science.
[2] Maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin.
[3] Numbers in parenthesis refer to the Literature Cited at the end of this report.

The Author: Henry Haskell received BS and MS degrees in forestry from Iowa State College. He is presently a technologist in the Division of Timber Processing at the Forest Products Lab. He is also a member of FPRS.

Fig. 2—The block-shear specimen under test in the hydraulic testing machine.

wood, ultimate joint strength, per cent of wood failure, the location of the failure in specimens constructed half of typical wood and half of tension wood, and the appearance of the broken joints. A control set of specimens tested at 8 per cent moisture content and a cycled set of specimens were used to evaluate the effect of changes in moisture content on the above properties. The cycling involved conditioning to 8 per cent moisture content, then to 20 per cent, and back to 8 per cent for two cycles. Testing was done after final conditioning at 8 per cent moisture content. Two of the glues, urea formaldehyde and resorcinol formaldehyde, are highly resistant to moisture and produce bonds of high strength. The third glue, polyvinyl resin, is an example of a glue that appears to be more resistant to moisture content changes than does a high-grade animal glue, but is still less resistant than the first two glues. This glue also shows some elasticity when subjected to moisture content changes.

Equipment: The equipment for gluing and testing the block-shear specimens was similar to that described in ASTM 905–49 and is in common use for testing adhesives (Fig. 2). The gluing equipment consisted of three bar-clamps with pressure adjusted by means of a torque wrench (Fig. 3).

More complex equipment was involved in the gluing and testing of the cross-lap specimens. A gluing rig

Fig. 3.—The bar clamps, wood cauls, and torque wrench used to make the block-shear specimens.

Fig. 4.—The cross-lap rig with test specimens.

(Fig. 4) that consisted of a heavy metal frame to keep the specimens to be glued in a column, a heavy-duty spring to maintain constant bonding pressure, and a spherical bearing block to distribute load to all parts of each joint, was developed by modifying the rig described by Marra (5). The testing equipment followed the requirements of ASTM D1344–54T in that it had independent bearing edges. Each bearing edge rocked on a semicircular surface, and thus was able to conform to the shape of the individual specimen under test (Fig. 5). Both shear and cross-lap test grips were used in a hydraulic, motor-driven testing machine of 60,000 pounds capacity.

Lumber: Carefully selected, defect-free, kiln-dried and conditioned lumber was ripped to 12¼ by 2¼ by 12 inch pieces (6). A classification of the rough-sawn surfaces of typical wood and tension wood is shown in Fig. 6. The cuttings were then jointed and planed to a thickness of 0.814 inch, or 0.064 inch thicker than the thickness of the specimens to be glued. This allowed for a final machining immediately before gluing. Before the cuttings were glued, they were randomly selected from the conditioning chamber, which was held at an equilibrium moisture content of 8 per cent. An equal number of specimens was made up of typical wood, tension wood, and typical wood to tension wood. Final planing to thickness was accomplished before each replication of the experiment was to be glued. Material for the cross-lap specimens was planed in width to 2.000 inches and to a thick-

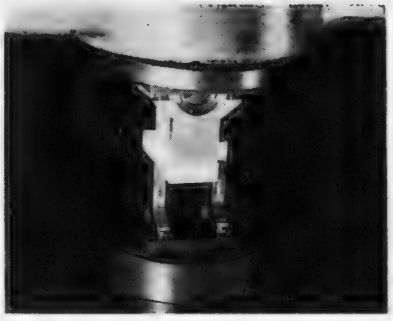

Fig. 5.—The cross-lap specimen under test in the hydraulic testing machine.

ness of 0.750 inch and then cross-cut to individual blocks of three inches in length. Cuttings for block-shear specimens needed only planing to the required thickness of 0.750 inch.

Gluing Surface Classification: The planed cuttings were classified as to the smoothness of their surfaces to be glued. A very smooth surface was described as good, while surfaces with checks, projecting fibers, or torn-grain apparently associated with the presence of varying amounts of tension wood fibers were described as moderately poor to poor (Figs. 7, 8A, and 8B). Some tension wood specimens produced gluing surfaces as smooth and good as those of typical wood specimens (Figs. 7A and 8C), which invariably produced smooth gluing surfaces. It was felt that the roughness of the poor gluing surfaces would interfere with proper adhesion and result in lower failing strength.

Because there were unequal numbers of tension wood specimens with good and poor gluing surfaces, the selection of specimens for bonding with each glue and each experimental replication was done at random.

Gluing: The glue was double spread by brush. The specimens were immediately assembled and then fitted into the gluing presses for both the cross-lap and the block-shear specimens. Ten minutes closed assembly time was used with each glue before the application of pressure. After pressure was applied, excess glue was removed from the edges of the joints and the specimens were allowed to stand overnight. On removal from the presses, the specimens were placed in the conditioning chamber and conditioned for two weeks at 8 per cent equilibrium moisture content.

Statistical Design: Analyses of variance were computed for each of the four replications with each glue, of each glue independent of replications, and of all glues. Interactions of typical wood and tension wood with test methods, equipment for manufacturing the test specimens, glues, and

Fig. 6.—Rough-sawn cottonwood lumber: A, typical wood; B, tension wood with a slight amount of projecting fibers; C, tension wood with a moderate amount of projecting fibers; D, tension wood with a heavy amount of projecting fibers.

cycling procedures were determined. All data presented here in tabular form was considered statistically, but for the sake of simplicity, statistical terminology is not employed.

Cycling and Testing: After the conditioning period following gluing, half the specimens of each type were removed for testing. The remaining specimens were subjected to a two-month moisture cycle of alternate weeks at 8 per cent and 20 per cent equilibrium moisture content. Testing of these specimens was accomplished in a manner similar to that used in the control group after the last 8 per cent conditioning.

Results

Comparing Tension Wood and Typical Wood Data: In selecting material for the project, cuttings containing knots and cross-grain were discarded. All specimens cut from typical wood produced gluing surfaces that were smooth and free of distortion. Rough sawn tension-wood lumber, however, produced surfaces with varying amounts of projecting fibers and collapsed areas (Fig. 7). In general, rough sawn tension-wood lumber that showed only small amounts of short, projecting gelatinous fibers produced planed surfaces that appeared to .be satisfactory for gluing. Rough sawn lumber that showed greater amounts and lengths of projecting fibers often produced rough planed surfaces.

Gluing Surfaces and Joint Strength: Typical-wood control specimens produced glue joints of slightly higher average strength than did tension wood (Table 1) in both shear (1,552 psi to 1,528 psi) and tension perpendicular to the grain (1,511 pounds to 1,488 pounds). These differences were not statistically significant. After the specimens were cycled, however, this slight difference in favor of typical wood disappeared. Good gluing surfaces produced bonds of greater average failing strength than did specimens with low-quality surfaces (Table 2). Much variation occurred, but there was less of a range of values with the good gluing surfaces of either typical wood or tension wood than with the tension-wood specimens with poorer gluing surfaces.

Fig. 7.—Planed cottonwood lumber: A, typical wood; B, tension wood with slight to moderate amounts of projecting fibers; C, tension wood with heavy amounts of projecting fibers.

Table 2 demonstrates that, within the tension-wood category, the condition of the gluing surface, as affected by projecting or torn-out fibers, was definitely a factor in reducing the failing strength of both types of joints. Good gluing surfaces on tension-wood specimens produced failing strengths as high as those of typical wood. This difference was less obvious after cycling, however. The failing strength values for the cross-lap specimens are given as the total rather than as a pounds per square inch value because of the tendency of the specimen and the test equipment to concentrate the stress at the edge of the specimen.

Fig. 8a.—Enlarged section of planed cottonwood lumber—tension wood with slight to moderate amounts of projecting fibers. Magnification is indicated by a millimeter scale along the top.

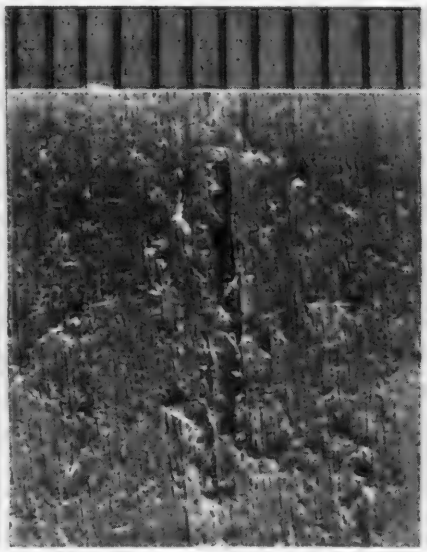

Fig. 8b.—Enlarged section of planed cottonwood lumber—tension wood with heavy amounts of projecting fibers, and showing surface check. Magnification is indicated by a millimeter scale along the top.

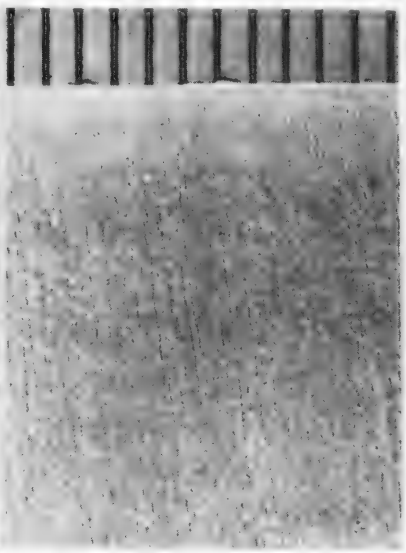

Fig. 8c.—Enlarged section of planed cottonwood lumber—typical wood. Magnification is indicated by a millimeter scale along the top.

Table 1.—AVERAGE* FAILING STRENGTH VALUES OF TYPICAL WOOD AND TENSION WOOD DETERMINED WITH TWO TYPES OF TEST SPECIMENS AND THREE RESIN GLUES

Type of wood in specimen	Glue 1†		Glue 2†		Glue 3†		All Glues	
	Control	Cycle	Control	Cycle	Control	Cycle	Control	Cycle
	Cross-lap specimen—pounds							
Typical	1379	1153	1470	1150	1685	813	1511	1039
Tension	1480	1212	1427	1125	1558	933	1488	1090
Glue Av.	1430	1183	1449	1138	1622	873	1500	1065
	Block-shear specimen—pounds per square inch							
Typical	1544	1656	1377	1658	1736	1689	1552	1668
Tension	1420	1595	1490	1653	1673	1738	1528	1662
Glue Av.	1482	1626	1434	1656	1705	1714	1540	1665

*Each value is an average of 24 specimens.
†Glue 1—resorcinol formaldehyde.
Glue 2—urea formaldehyde.
Glue 3—polyvinyl resin.

Tension Wood and Location of Failure in Joints: Cross-lap specimens constructed of one typical-wood and one tension-wood block failed more often on the tension-wood side (Table 3). The opposite result is obtained with shear specimens. It appears from these data that typical wood will fail in shear more readily than will tension wood, but that tension wood will fail more readily in tension perpendicular to the grain.

The Appearance of Joint Failures: The failure surfaces of joints constructed with typical wood were clean and smooth for the cross-lap specimens. Failure surfaces of the cross-lap tension-wood joints, however, showed varying degrees of projecting fibers (Fig. 9). It seems evident that the roughness of the failure surface is related directly to the abundance of gelatinous fibers. Some roughness was shown on failure surfaces of both typical-wood and tension-wood shear specimens. This was apparently caused by broken fibers being bent over along the grain and in the direction of shear (Fig. 10).

Wood Failure: Table 4 indicates that there is no consistent difference in the amount of wood failure between typical wood and tension wood. Both types of joints showed a marked tendency to fail in areas of heavy tension wood, however, particularly if collapse was present in the wood. The block-shear specimens, before and after cycling, produced large amounts of wood failure for all glues with both tension and typical wood. Only the polyvinyl resin (glue 3) lost in wood failure after cycling, and then by only about 25 per cent (Table 4.) In the cycled cross-lap specimens, however, polyvinyl resin glue showed a decrease in wood failure percentage of about 80 per cent while the other glues showed only slight increases (Table 4).

Discussion

The Differences Between Tension Wood and Typical Wood: The fact that cross-lap specimens made of a block of typical wood glued to a block of tension wood failed more often in the tension wood can possibly be explained on the basis of the physical and chemical properties of the fiber wall. Both typical and gelatinous or tension-wood fibers have similar primary walls, but the secondary walls differ in several ways. The typical fiber has a secondary wall that consists of three somewhat lignified layers while in tension-wood fibers, the inner or possibly all three layers of the secondary wall may have a peculiar structural composition and be known as a gelatinous layer.

The extent of the occurrence of tension-wood fibers is probably associated with the intensity of the stimulus causing them to develop. The peculiar layer is much lower in lignin content and higher in alpha cellulose than is the secondary wall of typical fibers. It is also rather loosely attached to the remainder of the cell wall. Since lignin probably tends to stiffen and strengthen wood in certain properties, it seems logical to assume that the difference in strength in tension perpendicular to the grain may be partially accounted for on this basis.

The rough and fuzzy appearance of the failure surface in cross-lap specimens of tension wood may also be due to the presence of the gelatinous layer in the fibers. In tension perpendicular to the grain, comparatively thin-walled typical-wood fibers are commonly pulled apart lengthwise (7). The gelatinous layer of tension wood, on the other hand, is more flexible and, being loosely attached to the remainder of the cell wall, adheres at some points along the broken fiber. It then pulls out of the rest of the cell wall and so is left projecting above the surface of the failure.

The location of failure in block-shear specimens consisting half of typical wood and half of tension wood occurred significantly more often in the normal wood. An explanation of this may center around the greater thickness and flexibility of the gelatinous layer of the fiber wall in tension wood. The thickness of the fiber wall is thought to be the dominant factor in determining shear strength of hardwoods. The tension-wood fiber may have the ability to give a little under load because of its thick, flexible, gelatinous layer. As a result, the tension wood may be able to absorb more stress.

The similarity in the appearance of failures of typical wood and tension wood in shear may be explained

Table 2.—COMPARISON OF AVERAGE* FAILING STRENGTH WITH PRE-GLUING SURFACE CONDITION OF TYPICAL WOOD AND TENSION WOOD IN TWO TESTS AND WITH THREE GLUES

Gluing surface condition	Glue 1†		Glue 2†		Glue 3†		All glues	
	Control	Cycle	Control	Cycle	Control	Cycle	Control	Cycle
	Cross-Lap Type-Wood Specimens—pounds							
Good	1379	1153	1470	1149	1685	812	1511	1039
Poor								
Average	1379	1153	1470	1149	1685	812	1511	1039
	Cross-Lap Tension-Wood Specimens—pounds							
Good	1533	1271	1513	1128	1620	856	1555	1085
Poor	1428	1138	1283	1133	1525	987	1399	1088
Average	1481	1205	1398	1131	1573	922	1477	1087
	Block-Shear Typical-Wood Specimens—pounds per square inch							
Good	1544	1656	1377	1658	1736	1689	1552	1668
Poor								
Average	1544	1656	1377	1658	1736	1689	1552	1668
	Block-Sheat Tension-Wood Specimens—pounds per square inch							
Good	1522	1775	1576	1693	1757	1690	1618	1719
Poor	1408	1607	1256	1459	1589	1801	1469	1637
Average	1465	1691	1416	1576	1673	1745	1544	1678

*Glue averages based upon 24 specimens each.
†Glue 1—resorcinol formaldehyde.
Glue 2—urea formaldehyde.
Glue 3—polyvinyl resin.

Table 3.—COMPARISON OF LOCATION OF FAILURE IN SPECIMENS CONSISTING OF HALF TYPICAL WOOD AND HALF TENSION WOOD

Location of failure	Number of specimens	
	Cross-lap	Block-shear
Typical wood	45	79
Tension wood	82	49
Intermediately	17	16
Total specimens	144	144
Chi-square	10.780*	7.032*

*Significant at 1 per cent level.

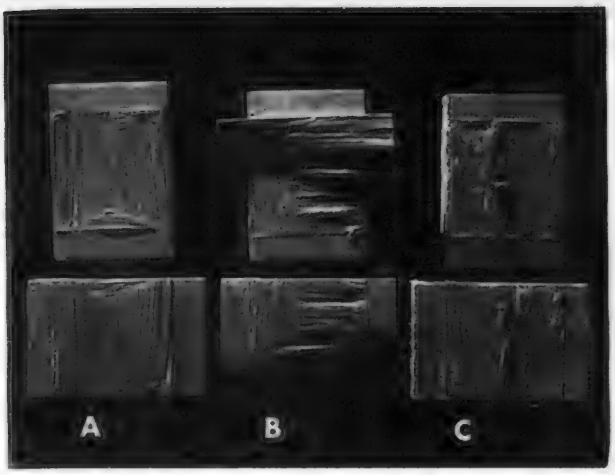

Fig. 9.—Tested cross-lap specimens showing the surface quality of the failure: A, smooth surface associated with typical wood; B, slight to moderate roughness associated with slight to moderate amounts of tension wood; C, heavy roughness associated with heavy amounts of tension wood.

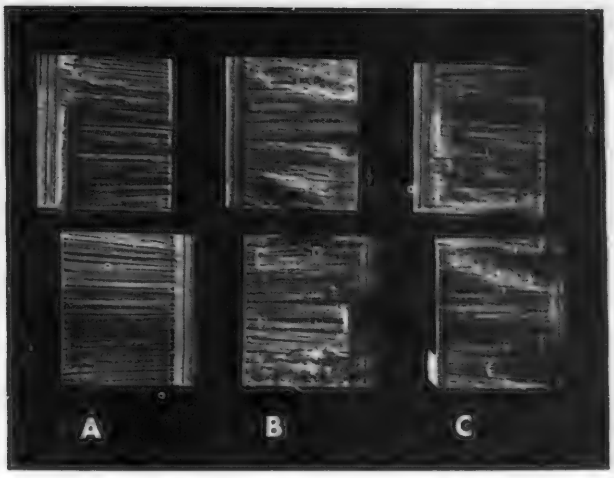

Fig. 10.—Tested block-shear specimen showing the surface quality of the failure: A, slight roughness generally associated with typical wood and slight amounts of tension wood; B, moderate roughness generally associated with moderate to heavy amounts of tension wood; C, heavy roughness and stringiness generally associated with heavy amounts of tension wood.

by the nature of the shearing force on wood. The failing strength and perhaps the appearance of the failure are directly related to the thickness of the fiber walls. The moisture content of the wood at the time of testing is also an important factor. Since all the wood used in this experiment was at nearly the same moisture content, however, it is assumed that this factor can be ruled out.

In seasoned wood subjected to shear stresses, comparatively thin-walled typical-wood fibers are commonly sheared apart lengthwise (7). The break will generally follow a single fiber for the greater part of its length. As the shearing action proceeds, the broken fibers are often bent over along their length. When the specimen halves are separated, the broken, bent fibers project from the failure surface. This occurs in a like manner in typical- and tension-wood fibers, but is intensified when large numbers of gelatinous fibers are present. This may be due to the separation of the gelatinous layer from the remainder of the cell wall. This layer would then project from the part of the fiber to which it was attached. A cluster of stringy fibers is often the result.

Glues: All glues used in this experiment gave high shear strengths before and after they were cycled. For the cross-lap specimens, resorcinol-formaldehyde and urea-formaldehyde glues showed no reduction in strength after cycling; polyvinyl glue gave considerably lower strengths and wood failure percentages, however. In cycling exposures, the cross-lap joint appears to give a far more rigorous test than the block-shear joint. This is no doubt due to the cross-lap construction, which develops maximum stresses as a result of shrinking and swelling. In the block-shear specimens, the grain of each specimen half is parallel, and this minimizes stresses during cycling. For this reason, perhaps, the block-shear specimens recover most of their strength after cycling, while the strength of the cross-lap specimens may drop off and show lower values of wood failure. A truer glue evaluation seems possible by use of the cross-lap specimen. The block-shear test for evaluation of glues would seem to give information that might be misinterpreted, particularly when cycling is involved.

Considering both types of test specimens, it is interesting to note that, in general, highest wood failures before cycling were obtained with the polyvinyl resin glue. The elasticity of this glue is a possible explanation.

The Cross-lap Specimen: Some disadvantages of the cross-lap specimen were noticed. Among the most important are:

1. Slight deviations of grain may cause cleavage-type failures to develop during the tests. Even though the maximum slope of grain of the wood was 1 in 24, the cross-lap specimens were still sensitive enough to give some cleavage-type failures. In these cases, deep wood failures often occurred without relation to the presence or absence of tension wood.
2. Greater variability of failure strength was obtained with this specimen than with the block-shear specimen.

Advantages of the cross-lap gluing device, other than those noted by Marra (4), appear to be as follows:

1. The equipment is compact and lends itself to moisture content control of the specimens during the curing period of the glue. After the specimens are glued, the whole assembly may be placed in a small conditioning chamber.
2. Better pressure control may be obtained in that pressure is applied at one focal point. With the block-shear specimen, however, pressure in most cases must be re-applied after the initial application to compensate for the drop-off in pressure that results from

Table 4.—COMPARISON OF AVERAGE WOOD FAILURE PERCENTAGES OF TYPICAL WOOD AND TENSION WOOD DETERMINED WITH TWO TYPES OF TEST SPECIMEN AND THREE GLUES *

Type of wood in specimen	Glue 1†		Glue 2†		Glue 3†		All glues	
	Control	Cycle	Control	Cycle	Control	Cycle	Control	Cycle
	Average wood failure in per cent							
	Cross-lap specimens							
Typical	89	97	89	96	99	10	92	68
Tension	91	96	87	98	99	27	92	74
Glue average	90	97	88	97	99	19	92	71
	Block-shear specimens							
Typical	94	98	96	97	100	74	97	90
Tension	96	99	94	96	100	81	97	92
Glue average	95	99	95	97	100	78	97	91

*Averages based upon 24 specimens each.
†Glue 1—resorcinol formaldehyde.
Glue 2—urea formaldehyde.
Glue 3—polyvinyl resin.

the squeeze-out of glue. The pressure theoretically is maintained in the cross-lap rig by the incorporation of the spring. The spherical bearing block built into the rig allows uniform loads to be applied to all bonds and parts of bonds within the rig. In the multi-clamp arrangement used in gluing block-shear specimens, variations in pressure may occur at different locations within the same load of specimens.

Conclusions

The objective of this experiment was to study certain physical properties of tension wood in cottonwood. An improvement of methods of gluing and testing wood specimens was also undertaken.

The more important conclusions of this investigation are as follows:

1. As indicated by location of failure in tension wood—typical wood joints, tension wood appears to fail more readily than typical wood when tested in tension perpendicular to the grain.

2. Typical wood appears to fail more readily than tension wood when tested in shear.

3. The actual failing strength values for both types of test specimen do not differ significantly for tension wood and typical wood. In wood containing large amounts of tension wood, it is doubtful that this would hold true, however.

4. With the cross-lap specimens, the appearance of the failure surface seems to be a good indicator of the presence or absence of tension wood.

5. The failure surface of block-shear specimens possessed short projecting fibers in both typical and tension wood. Only with the occurrence of clumps of gelatinous tissues can tension wood be readily identified in shear-tested joints.

6. For the usual type glued wood joints, cottonwood that contains moderate amounts of tension wood appears to be satisfactory from the strength point of view. Large amounts of tension wood are often associated with low joint strength, however. Also, this does not take into consideration the problem associated with the abnormal shrinkage and swelling properties of tension wood.

7. There are indications that typical wood, in tests involving both shear and tension perpendicular to the grain, gives more uniform failing strength values than does tension wood.

8. The equipment used for gluing and testing joints in tension perpendicular to the grain was very satisfactory.

9. After specimens are cycled, the block-shear test appears to give misleading information so far as joint strengths and wood failures are concerned. With the block-shear test, high failing strength values were obtained before and after cycling, whereas in the cross-lap test, all glues show a decrease in failing strength and amounts of wood failure after cycling. This is particularly true of the polyvinyl resin glue. This difference appears to be due to the ability of the cross-lap specimen to concentrate stresses at the glue line.

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The Relation of Mechanical Properties of Wood and Nosebar Pressure in the Production of Veneer[1,2]

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Observations of checking frequency, depth of check penetration, veneer thickness, and surface quality were made at 20 machining conditions. An inverse relationship between depth of check and frequency of checking was established. The effect of cutting temperature was demonstrated, and strength in compression perpendicular to the grain, tension perpendicular to the grain, and rolling shear was determined at 4 temperatures. The mechanics of veneer formation is discussed with respect to the 2 basic veneer types observed.

WOOD VENEERS REPRESENT, in our present-day economy, a product of countless commercial and industrial applications. Furniture, plywood, molded veneer products, boxes and crates are, to mention but a few, well-established uses of veneer.

Although veneer is a common and accepted wood product, little basic research has been directed toward an understanding of the veneer-cutting process. Information accumulated in the past, although of recognized value, has largely been obtained from experience. Lathe checks, surface irregularities, thickness limitations, and varied production techniques are present obstacles to continued industrial progress.

It follows that basic research in the field of veneer-cutting is needed. It is obvious, however, that a comprehensive study of the many aspects of veneer-cutting would be of a magnitude beyond the scope of an individual research effort. The work described herein, therefore, endeavors to establish what takes place when wood is cut into veneer, and pursues the relationships of mechanical properties of wood and nosebar pressure. The study is directed primarily to a consideration of the rotary-cutting process.

Review of the Literature

Although numerous publications may be found in veneer-cutting literature pertaining to production methods and techniques, only limited material concerning the fundamental aspects of veneer formation has been published.

Rotary veneer-cutting studies by Fleischer (1)[3] have revealed that an optimum knife angle exists for a given species and thickness to produce veneer with a smooth, uniform surface. Further, Fleischer has shown that, in general, the cutting angle should increase as the thickness of the veneer cut decreases, and that a reduction in the horizontal nosebar opening will result in veneer that contains fewer lathe checks per inch.

Kivimaa (2), by use of a tensile test to determine veneer quality, has demonstrated that an optimum nosebar opening exists for a given species.

In work concerning veneer smoothness, Lutz (3) has shown that smoothness of knife-cut veneer is affected by the orientation of wood fibers, the annual rings, and the wood rays with respect to the plane of the cut.

Behavior of individual wood cells during slicing has been investigated in Canada (4). Wood cells were observed to be compressed by the nosebar and knife edge and by the resistance caused by friction against the nosebar face and the knife back. In addition, important tension stresses were observed acting in front of the knife edge in an approximately radial direction.

The investigations summarized above provide plausible foundation to assume that mechanical properties of wood are an important factor in the veneer-cutting process.

Nomenclature

Considerable confusion exists in the veneer industry as to the application of various descriptive terms used in the veneer-cutting process. Because of the common use of several manufacturing methods and the ambiguities of tool geometry, a description of cutting nomenclature is a necessary antecedent to further discussion.

The terminology adopted for use in this study is defined below, with geometrical relationships shown in Fig. 1.

Line AB—A line perpendicular to a line tangent to the work and passing through the cutting edge of the knife.

C— Cutting angle, the angle between the face of the knife and line AB.

D— Sharpness angle of the knife.

E— Clearance angle, the angle between the back of the knife and line AB.

F— Vertical nosebar opening, the vertical distance between the maximum point on the nosebar and a plane described by the cutting edge of the knife.

G— Nosebar bevel, the angle between the nosebar and the horizontal.

H— Horizontal nosebar opening, the horizontal distance between the nosebar and Line AB.

Cutting velocity—The velocity of the work piece relative to the knife and nosebar.

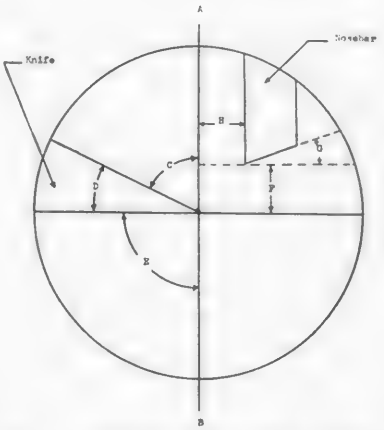

Fig. 1.—Geometrical relationships in orthogonal cutting of veneer.

[1] Second-place winner in the 1957 Wood Award competition.

[2] A condensation of a thesis submitted for the degree of Master of Wood Technology at the University of Michigan.

The Author: Charles McMillin obtained his BS degree from Purdue University. He received his Master of Wood Technology from the University of Michigan in 1957, and is currently engaged in machining research.

[3] Numbers in parentheses refer to Literature Cited at the end of this paper.

Purpose and Approach

The purpose of this study was to indicate how mechanical properties of wood and nosebar openings affect the quality of wood veneer.

Exploratory cutting investigations suggested several general areas of research. Both horizontal and vertical nosebar openings, as well as cutting angle, were observed to effect veneer quality. Further, it was indicated that higher cutting velocities may materially increase checking.

While it is recognized that all the above factors influence the veneering process, it was necessary that a limitation of scope be imposed to consider only those variables within the magnitude of an individual study.

The vertical opening was determined to be the more critical nosebar adjustment, and was selected as a variable while horizontal nosebar opening was held constant. In addition, it was felt that more informative data would be obtained if cutting velocity and cutting angle closely approximated current practice.

Further, it was recognized that the use of production-size equipment presented serious limitations in both experimental design and control of cutting variables. A method was needed to produce veneer on a small, experimental scale with precise control of cutting conditions. Orthogonal cutting perpendicular to the grain, as suggested in the wood-machining literature by Franz (5), presented a favorable solution to the problem.

In orthogonal cutting of veneer, the knife edge and nosebar are perpendicular to the direction of relative motion of the cutting fixture and work piece. This generates a plane surface parallel to the original work surface. If a small segment of the outer periphery of a large veneer bolt is considered to approach a straight line, small veneer strips produced experimentally by orthogonal cutting may be considered analogous to veneer produced by the rotary-cutting process.

During the cutting of veneer, preliminary observations indicated that, among other stresses, the knife may induce stresses in the wood in tension perpendicular to the grain, compression perpendicular to the grain, and rolling shear. Concurrently, the nosebar may produce stress in compression perpendicular to the grain and rolling shear. It follows that the strength of a given species in these properties is an important consideration in analyzing the cutting characteristics of the wood.

Most strength properties of wood decrease as temperature increases. The degree of strength change has been demonstrated to bear a linear relationship to specific gravity and moisture content. Sulzberger (6) has shown that, for a number of species tested at 15 per cent moisture content, maximum crushing strength, modulus of rupture, and modulus of elasticity decrease from about 2.5 to 5.0 per cent for each 10° F. temperature change. Greenhill's (7) studies of the relation of temperature and moisture content on wood properties reveal that, at 180° F., the tensile strength and modulus of elasticity perpendicular to the grain are reduced ⅓ to ½ of their value at room temperature.

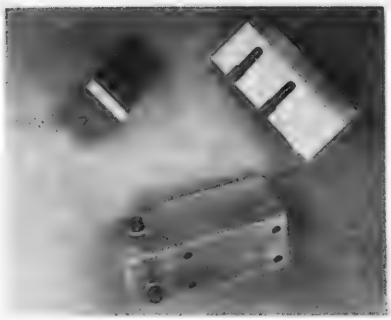

Fig. 2.—Disassembled orthogonal veneer-cutting fixture, showing knife, nosebar, and mounting.

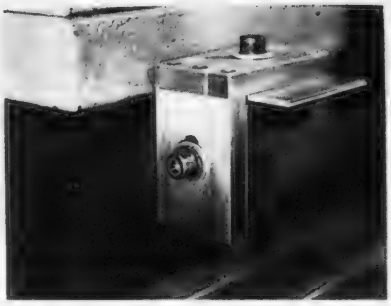

Fig. 3.—Assembled orthogonal veneer-cutting fixture showing method of using references faces to position the nosebar.

Therefore, by altering the temperature of several woods while cutting at various vertical nosebar openings, it was possible to study how veneer quality was affected by the relationships of wood mechanical properties and nosebar pressure.

Experimental Procedure

Design of the Experiment: A total of 20 cutting conditions with three replications were used to study the interaction of mechanical properties and nosebar pressure. The following experimental design was adopted:

1 Species—Yellow birch *(Betula lutea* Michx. f.) heartwood and sapwood, and redwood *(Sequoia sempervirens* D. Don Endl.).
2 Nosebar opening—Vertical, 0, 3, 6, 9, 15 per cent less than the veneer thickness; Horizontal, 0.025 inches.
3 Temperature—80°, 120°, 160°, and 200°.
4 Veneer thickness—0.125 inch.
5 Clearance angle—90 degrees.
6 Cutting angle—70 degrees.
7 Sharpness angle—20 degrees.
8 Nosebar angle—15 degrees.
9 Cutting velocity—67 feet per minute.
10 Mechanical tests—Tension perpendicular to the grain, compression perpendicular to the grain, and rolling shear.

The above species were selected to represent a hardwood and a softwood both of commercial importance and of widely divergent physical and mechanical properties. Both the sapwood and heartwood of yellow birch were selected for consideration since field observations indicate that each displays distinct veneering characteristics.

Vertical nosebar openings were selected to represent a range from zero pressure to pressure resulting in overcompression of the veneer. Geometrical cutting relationships were selected from current veneer-cutting practice.

In addition, limited consideration was given to the determination of the coefficient of friction for the above-mentioned woods. This was deemed necessary, since previous wood-machining studies have indicated the importance of frictional forces (5).

Orthogonal Veneer-Cutting System: Because orthogonal cutting of veneer necessitated the development of a new approach to veneer research, a detailed description of the cutting fixture is necessary.

Any cutting system developed should meet the following general requirements: 1) the system must allow for accurate, easy adjustment of the nosebar in both the horizontal and vertical directions, 2) deflection of the nosebar and knife as a result of cutting forces must be at a minimum, 3) the device must be of sufficiently heavy construction to allow secure positioning of the

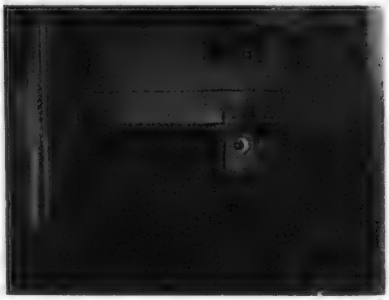

Fig. 4—Orthogonal veneer-cutting system showing cutting fixture, milling machine and vise.

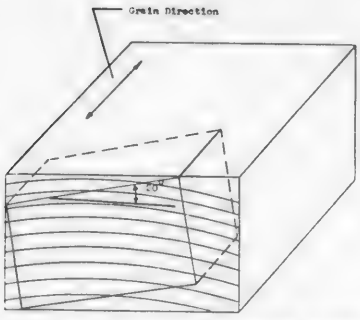

Fig. 5.—Sketch showing method of cutting veneer test specimens to obtain a favorable growth ring orientation.

knife and nosebar, and 4) the system must incorporate a means for obtaining accurate and uniform relative motion between the cutting edge and the work.

The cutting fixture developed is pictured in Figs. 2 and 3. Precise positioning of the nosebar and knife may be accomplished with two accurately machined reference faces. The knife, attached to the bottom surface by two large bolts, was slotted so that after sharpening it could be moved forward to the plane of the reference face from which horizontal nosebar adjustment was determined. The nosebar was adjusted in both the horizontal and vertical directions by shims placed on the two reference faces. The cutting angle was determined by the angle between the bottom face and the horizontal.

A milling machine provided a satisfactory method of traversing the work piece while holding the cutting apparatus stationary. The specimens were held in place by a vise affixed to the milling-machine table. The cutting fixture was mounted on an extension of the machine head after the arbor had been removed. By movement of the table, a portion of the specimen passed between the knife and nosebar to form a small veneer strip. Fig. 4 pictures the assembled orthogonal cutting system.

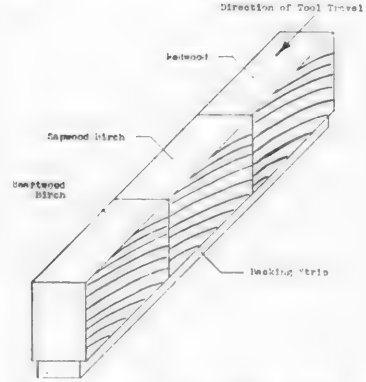

Fig. 6.—Sketch showing work piece unit consisting of a specimen of sapwood and heartwood yellow birch and redwood.

Preparation of Test Specimens: In the selection of material for study, it was necessary to impose several restrictions to minimize variation in wood properties and to facilitate accurate analysis of the influence of wood properties on veneer quality. The following restrictions were placed on all test material: 1) only straight-grained, defect-free, even-growth material was used, 2) all veneer and mechanical test specimens were end-matched to minimize specific gravity variation, and 3) all specimens were taken from the same band of growth rings.

Samples of redwood, heartwood yellow birch, and sapwood yellow birch that meet the above requirements were obtained in the green condition and stored in vapor-proof wrapping until cut into test specimens. Green wood was selected so that the test material would be reasonably free from internal defects and stresses resulting from drying. Each board was cut into three parts, veneer-cutting specimens being cut from the central portion, and mechanical test specimens from the end portions.

The veneer test specimens, 4 inches by 2½ inches across the grain and 1½ inches along the grain, were cut from the stock with the growth rings orientated at an angle of approximately 20 degrees to the surface to be machined (Fig. 5). A veneer test specimen from each of the three wood samples was then attached to a backing strip for convenience in handling (Fig. 6), with the growth rings positioned so that the springwood portion of each increment would first be presented to the tool edge. Thus, a uniformly favorable cutting condition was obtained in accordance with the findings of Lutz (3). The composite work unit was held in water at room temperature until use to make certain the material remained above the fiber saturation point.

Two specimen blanks for each of the three types of mechanical tests to be conducted at the four temperature levels were cut from the end portions of each wood sample.

A cleavage specimen was used to determine strength values in tension perpendictular to the grain, since it was reasoned to be a more realistic test than the standard tension specimen (5, 8). In both the cleavage and the shear-test specimens, certain departures from standard dimensions were necessary as a result of the saturated moisture condition and the manner of grain orientation (Fig. 7). Standard test-specimen dimensions were used to determine compression perpendicular to the grain (8).

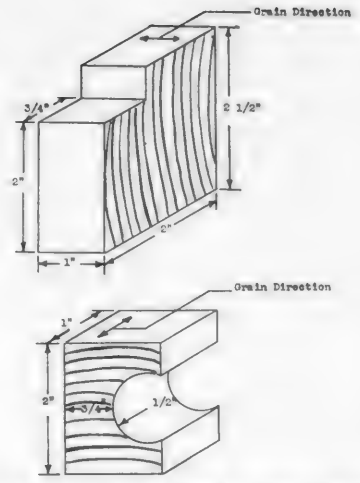

Fig. 7.—Sketch showing dimensions and grain orientation for rolling shear and cleavage test specimens.

All mechanical test specimens were stored in water at room temperature until used at the various temperature levels. Standard procedures were used to compute the individual mechanical properties.

Temperature Control: Temperature control for mechanical properties tests was accomplished by means of controlled-temperature baths. Before the specimens were tested, they were heated for two hours in water of the specified temperature. The specimens were then removed from the water and immediately tested. Preliminary experiments showed that the temperature drop during testing was negligible and that accurate values could be obtained in this manner.

A more complex means of temperature control was required during veneering. Before the veneer was cut, the work unit was heated in water of specified temperature for a period of two hours. Because of inherent delays in experimental procedure, the opportunity for temperature loss existed during cutting of the veneer strips. An external source of heat was therefore required to maintain the test specimens at a constant temperature. To accomplish this, a heavily insulated container with an electrical heating unit and thermostatic control was developed (Fig. 8). Water from the container was fed to a spray unit mounted in front of the work piece (Fig. 9), thus permitting the heated water to flow over the work and maintain the desired specimen temperature.

Method of Cutting: Prior to cutting, the sharpened veneer knife was advanced to the lower edge of the reference face, from which the horizontal nosebar opening was determined, and was securely bolted to the assembly. Precautions were taken to

Fig. 8.—General view of the experimental area, showing heating container for maintaining constant temperature during cutting of veneer.

Fig. 9.—Water spray unit for maintenance of specimen temperature during cutting.

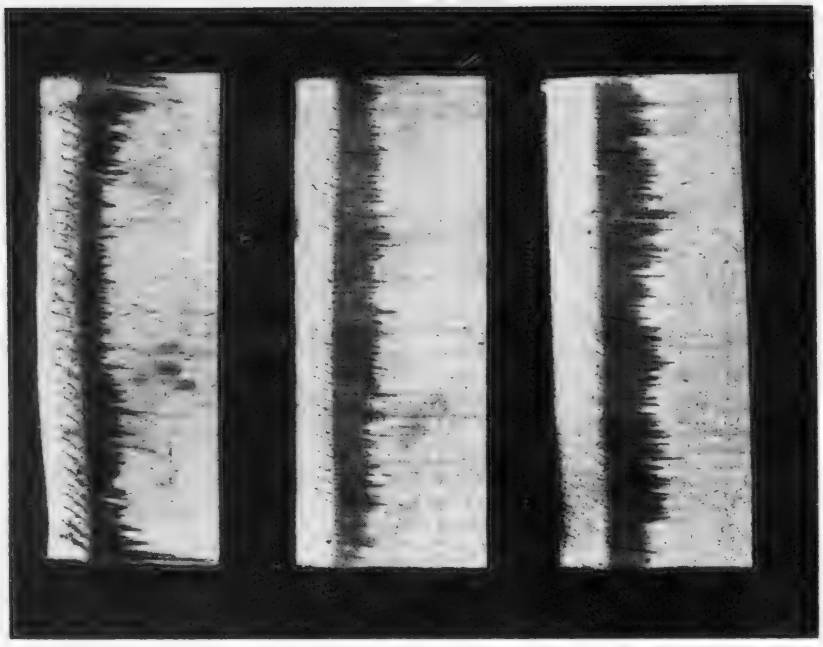

Fig. 10.—Veneer strips produced by orthogonal cutting, showing scarfed edge and exposed lathe checks.

make certain the fixture established accurate orthogonal cutting conditions.

Sufficient shim stock was placed on the top reference face to raise the extreme edge of the nosebar to the cutting edge of the knife. By placing additional shim stock on the two reference faces, precise horizontal and vertical nosebar adjustment was accomplished. Adjustments of the nosebar were made during cutting at higher temperatures to compensate for thermal expansion of the cutting fixture.

The heated work unit of wood specimens was securely mounted in the vise, and water of specified temperature was allowed to flow over the work unit as previously described. Several light cuts were made to assure a parallel surface with respect to the cutting edge of the knife. The milling-machine table was then raised 0.125 inch, and the work unit was advanced past the nosebar and knife. One veneer strip was cut and discarded to assure that the test veneer would have characteristic surface quality. After measurements were made for green thickness, the veneer strips were numbered consecutively for identification and placed under wire screens in a 16 per cent equilibrium moisture content conditioning room for a period of two weeks.

Additional consideration was given to the determination of instantaneous tool forces induced on the knife during cutting by employing a two-component dynamometer. The dynamometer and experimental method employed is described in an analysis of the wood-cutting process by Franz (5).

Interpretive Techniques: To be considered of the highest quality, veneer must be 1) of minimum surface roughness, 2) uniform in thickness, and 3) free from lathe checks. It was recognized that the variables under consideration would produce veneer that would fail in one or more of the above considerations. It was therefore felt desirable to have three independent measures of veneer quality.

The frequency and depth of lathe checking was determined for each veneer strip. By lightly staining the loose side with a fast-drying alcohol stain and beveling a half-inch surface on

Table 1.—SUMMARY OF QUALITY DETERMINATIONS FOR SAPWOOD YELLOW BIRCH MACHINED AT VARIOUS NOSEBAR OPENINGS AND TEMPERATURES

Temp., ° F.	Nosebar opening, per cent	Checking frequency	Depth of check, in.	Dry thickness, in.	Green thickness, in.
80	0	10.5	0.079	0.124	0.129
80	3	12.0	0.069	0.124	0.129
80	6	13.3	0.062	0.124	0.128
80	9	17.0	0.049	0.123	0.126
80	15	22.0	0.031	0.116	0.121
120	0	10.4	0.059	0.123	0.128
120	3	12.0	0.055	0.124	0.129
120	6	15.0	0.033	0.123	0.128
120	9	19.0	0.023	0.122	0.127
120	15	23.0	0.018	0.114	0.118
160	0	10.0	0.048	0.131	0.136
160	3	14.5	0.032	0.123	0.128
160	6	16.0	0.028	0.120	0.125
160	9	21.0	0.022	0.120	0.124
160	15	27.5	0.015	0.114	0.119
200	0	16.5	0.028	0.129	0.133
200	3	33.0	0.021	0.126	0.129
200	6	39.0	0.020	0.123	0.126
200	9	51.0	0.013	0.121	0.125
200	15	0	0	0.118	0.121

Table 2.—SUMMARY OF QUALITY DETERMINATIONS FOR HEARTWOOD YELLOW BIRCH MACHINED AT VARIOUS NOSEBAR OPENINGS AND TEMPERATURES

Temp., ° F.	Nosebar opening, per cent	Checking frequency	Depth of check, in.	Dry thickness, in.	Green thickness, in.
80	0	8.7	0.088	0.124	0.129
80	3	11.0	0.083	0.124	0.130
80	6	12.3	0.073	0.124	0.130
80	9	15.7	0.049	0.122	0.127
80	15	22.0	0.027	0.118	0.123
120	0	9.0	0.080	0.124	0.130
120	3	10.7	0.072	0.124	0.130
120	6	14.0	0.052	0.121	0.127
120	9	15.0	0.040	0.118	0.125
120	15	18.7	0.029	0.114	0.120
160	0	9.3	0.066	0.130	0.137
160	3	10.7	0.045	0.121	0.128
160	6	16.3	0.023	0.121	0.127
160	9	20.3	0.022	0.121	0.127
160	15	50.0	0.012	0.117	0.123
200	0	16.0	0.024	0.125	0.130
200	3	23.0	0.015	0.124	0.129
200	6	25.0	0.014	0.120	0.125
200	9	39.0	0.007	0.120	0.125
200	15	0	0	0.119	0.124

the stained edge (9), lathe checks were exposed as dark lines extending through the thickness of the veneer (Fig. 10). The number of checks exposed over a 3-inch length was determined, and the frequency of checking was expressed as checks per inch of length. The average depth of check penetration was determined by applying the ratio of bevel length and dry thickness to the average length of the checks exposed on the scarfed surface.

Veneer thickness was determined at 5 equi-distant points along the length of the veneer strip in the green and dry condition with micrometer calipers. The thickness of the veneer was considered to be the average of the five measurements. Visual examination served to establish surface quality.

Results of Veneer Quality Determinations

As previously implied, machining conditions were such as to produce veneer of a wide range of quality. Data obtained from quality determinations are summarized in Tables 1 through 3. Relationships and trends extracted from these data are shown graphically in Figs. 11 through 14.

From the data, it will be noticed that veneer thickness measured in the green condition was greater than the nominal cutting dimension of 0.125 inch. It was observed that the increased thickness was accompanied by a corresponding shortening of the veneer along the cutting direction. These phenomena are similar to those in the machining of metals as described by Merchant (10).

Table 3.—SUMMARY OF QUALITY DETERMINATIONS FOR REDWOOD MACHINED AT VARIOUS NOSEBAR OPENINGS AND TEMPERATURES

Temp., ° F.	Nosebar opening, per cent	Checking frequency	Depth of check, in.	Dry thickness, in.	Green thickness, in.
80	0	6.5	0.123	0.130	0.132
80	3	7.5	0.115	0.129	0.130
80	6	9.0	0.107	0.129	0.130
80	9	10.5	0.100	0.127	0.128
80	15	12.0	0.098	0.122	0.124
120	0	6.0	0.089	0.129	0.130
120	3	8.0	0.083	0.127	0.130
120	6	10.0	0.075	0.127	0.129
120	9	12.5	0.070	0.126	0.127
120	15	13.0	0.044	0.121	0.123
160	0	0	0	0.129	0.132
160	3	0	0	0.129	0.131
160	6	0	0	0.128	0.130
160	9	0	0	0.127	0.128
160	15	0	0	0.124	0.126
200	0	0	0	0.129	0.130
200	0	0	0	0.126	0.129
200	6	0	0	0.125	0.128
200	9	0	0	0.125	0.127
200	15	0	0	0.122	0.124

The reduction in veneer thickness with smaller nosebar openings suggests that the attending pressures were sufficient to cause compression set of the wood fibers. Due to the rigidity of the nosebar, the amount of wood compression was positive, and deformation rather than strength in compression perpendicular to the grain appears to be the limiting factor. This is evidenced by measurements of green and dry thickness dimensions, which display relatively uniform differences at all nosebar pressures and thus reflect uniform shrinkage from the green thickness during drying.

An interrelationship appears to exist between temperature, nosebar pressure, checking frequency, and depth of check penetration. Checks of low frequency were characteristically severe in penetration, while checks of high frequency were relatively shallow. Figs. 11 through 14 reveal that lathe checking was materially reduced by increasing nosebar pressure or cutting temperature.

In general, the surface roughness of all woods tested decreased with an increase in temperature or nosebar pressure. In the case of yellow birch, surface quality appeared related to the severity of checking. Shallow checks of high frequency were in all cases indicative of good surface quality. With redwood, however, surface quality did not appear to be so closely correlated with checking. Although no checking was observed when machining was done at 160° F., surface roughness was severe and only slight improvement was noted when veneering at 200° F.

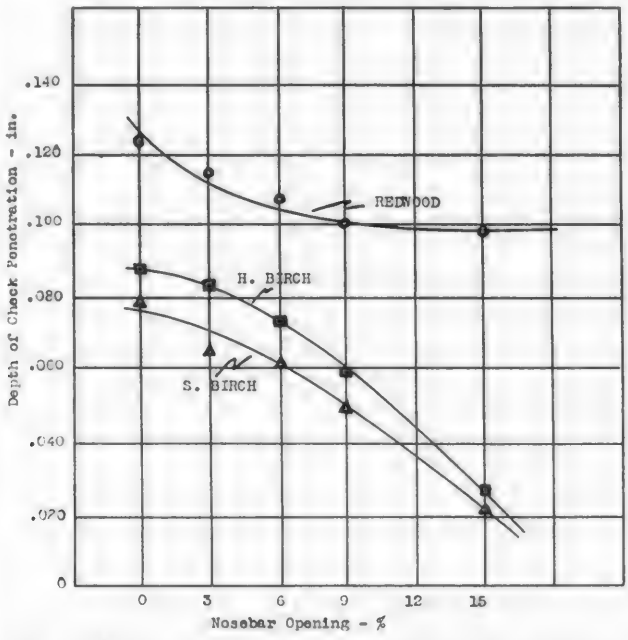

Fig. 11.—Relation of nosebar pressure to depth of check penetration for woods machined at 80° F.

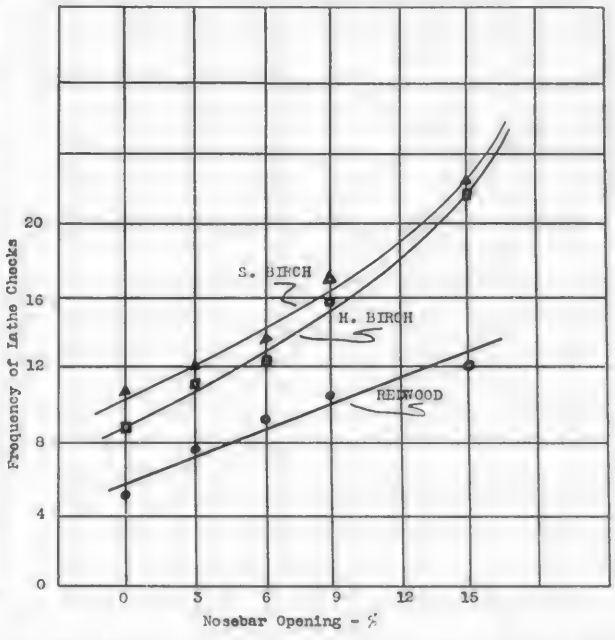

Fig. 12.—Relation of nosebar pressure to frequency of lathe checks for woods machined at 80° F.

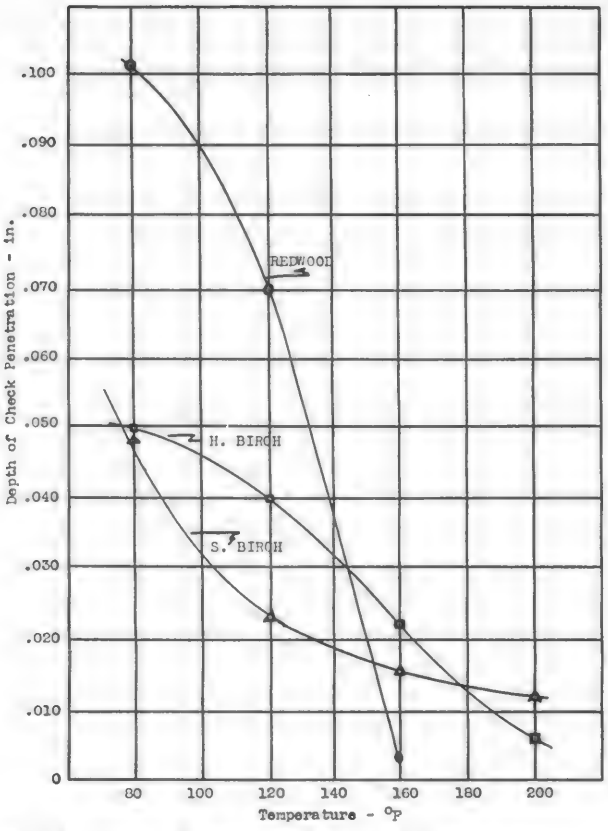

Fig. 13.—Relation of temperature to depth of check penetration for woods machined with vertical nosebar opening of 9 per cent.

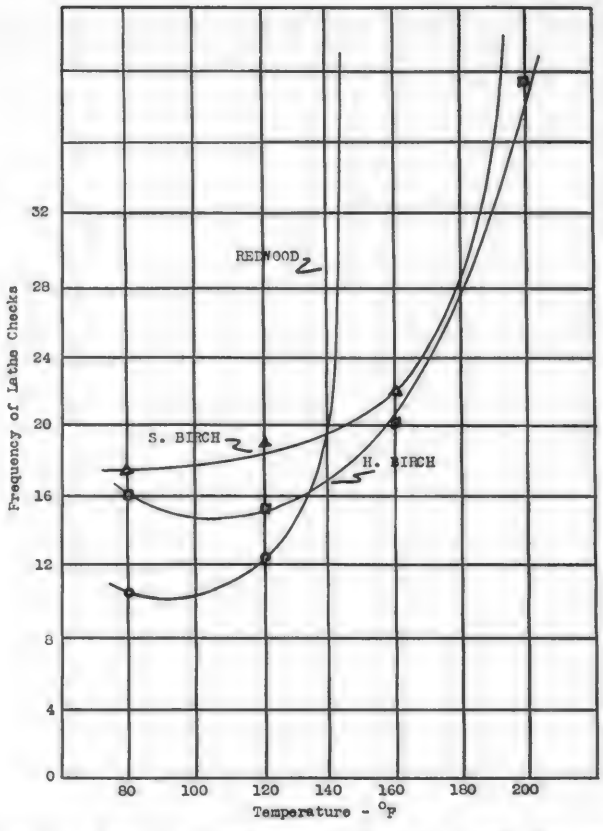

Fig. 14.—Relation of temperature to frequency of lathe checks for woods machined with vertical nosebar opening of 9 per cent.

Results of Mechanical Properties Tests

The mechanical properties and coefficient of friction for redwood, sapwood yellow birch, and heartwood yellow birch were determined at the prescribed temperature levels. Data obtained are summarized in Table 4 with graphical representations shown in Figs. 15 through 18. Only those properties considered to be pertinent to the veneer-cutting process are included.

The tensile stress in cleavage was caluculated by the equation for eccentric loading (11),

$$S = \frac{F}{A} + \frac{Fec}{I}$$ where,

S = stress in tension, in pounds per square inch
F = the applied load, in pounds
A = the area under stress, in square inches
e = the eccentricity of the applied load, in inches
c = the centroidal distance of area A, in inches
I = moment of inertia of area A.

The coefficient of friction was calculated from the equation used by Franz (5) in a study of the wood-cutting process.

$$u = \tan\left(\arctan\frac{K_n}{K_p} + C\right)$$

u = the coefficient of friction
K_n = the normal force component on the knife
K_p = the parallel force component on the knife
C = the cutting angle

It may be noted that values obtained for the coefficient of friction are very high, and in some cases greater than one. Similarly high values for the coefficient of friction have been reported by Ernst and Merchant in metal machining studies (12).

Discussion of Observational Data

Veneer Type: It has been shown in previous wood-machining experiments that the cutting process is defined by the nature of wood failures ahead of the cutting edge, and that these failures are a function of wood mechanical properties and cutting geometry (5). These findings can be demonstrated to be applicable to the veneering process. Observations made during the formation of veneer show that basic veneer types are generated which display identifying characteristics. It is suggested, therefore, that veneer type can be associated to wood properties and cutting conditions by means of analysis of force relationships.

Two basic types of veneer were distinguishable in this study:

Table 4.—SUMMARY OF MECHANICAL PROPERTIES AND COEFFICIENT OF FRICTION DETERMINED FOR WOODS TESTED AT VARIOUS TEMPERATURES

Temp., ° F.	Tension perpendicular to the grain psi	Rolling shear psi	Compression perpendicular to the grain psi at P.L.	Coefficient of friction
	REDWOOD			
80	320	241	315	1.18
120	260	202	272	1.05
160	192	169	240	1.32
200	141	128	161	
	SAPWOOD YELLOW BIRCH			
80	937	619	684	0.99
120	696	572	579	0.86
160	571	483	339	0.81
200	360	340	261	
	HEARTWOOD YELLOW BIRCH			
80	917	513	747	0.87
120	792	445	517	0.71
160	596	350	409	0.78
200	390	259	297	

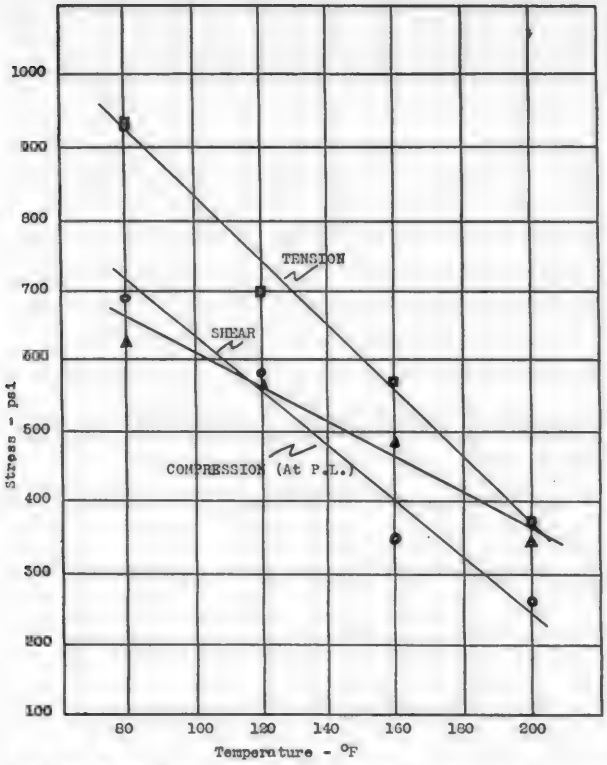

Fig. 15.—Relation of sapwood yellow birch mechanical properties to temperature.

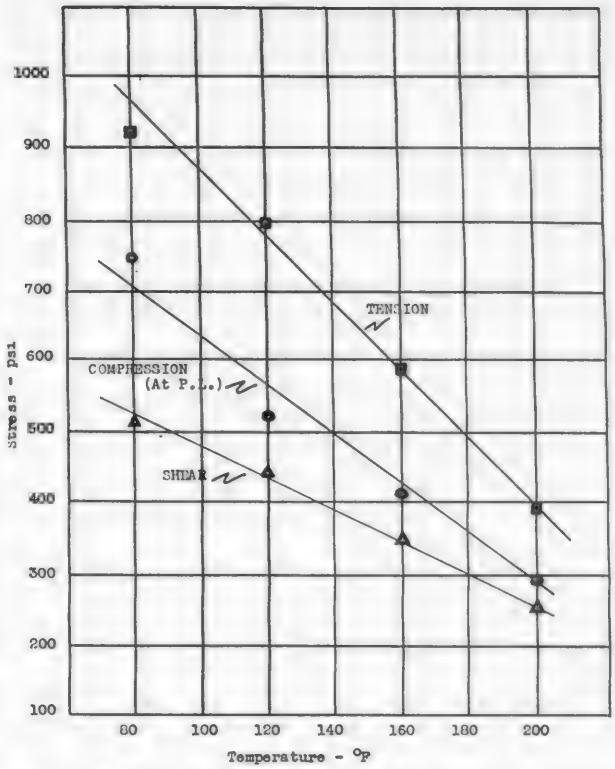

Fig. 16.—Relation of heartwood yellow birch mechanical properties to temperature.

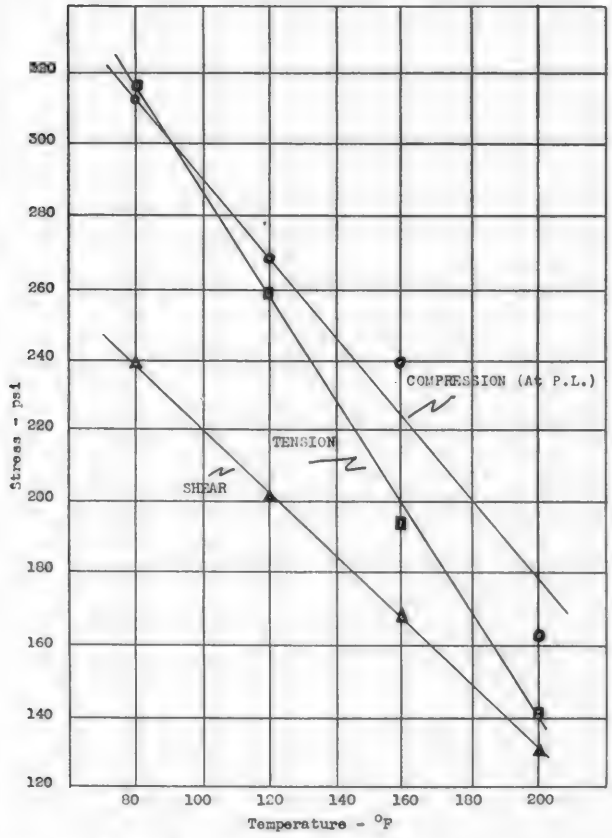

Fig. 17.—Relation of redwood mechanical properties to temperature.

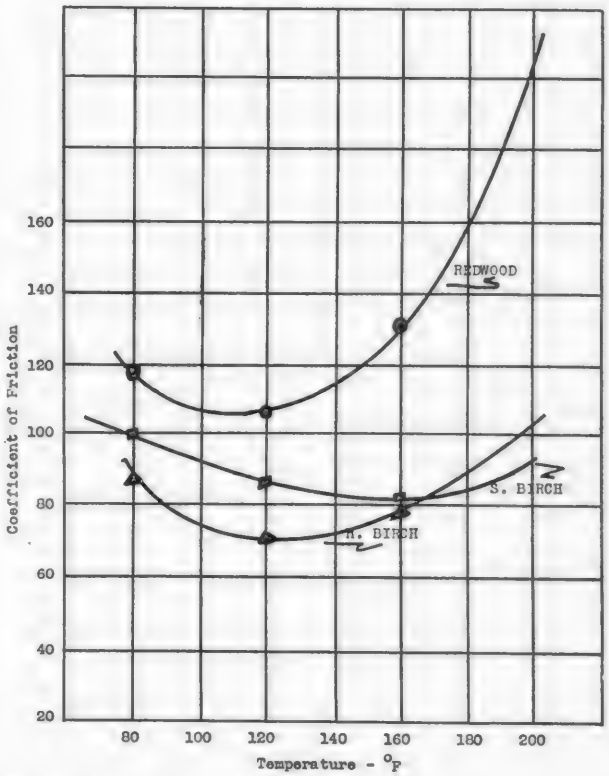

Fig. 18.—Relation of coefficient of friction of woods tested to temperature.

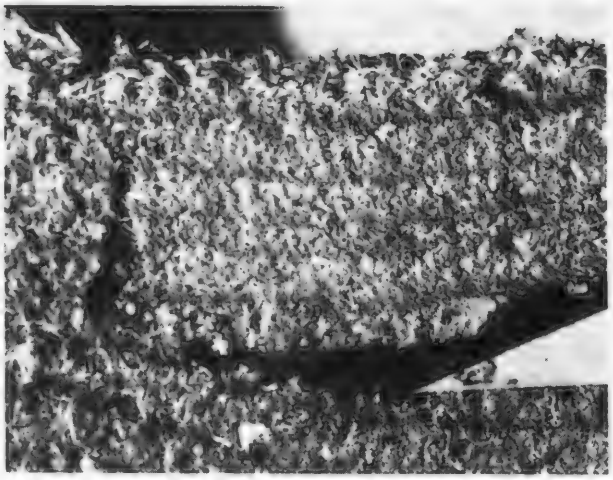

Fig. 19.—Type A veneer, showing split portion ahead of the knife and failure as a beam.

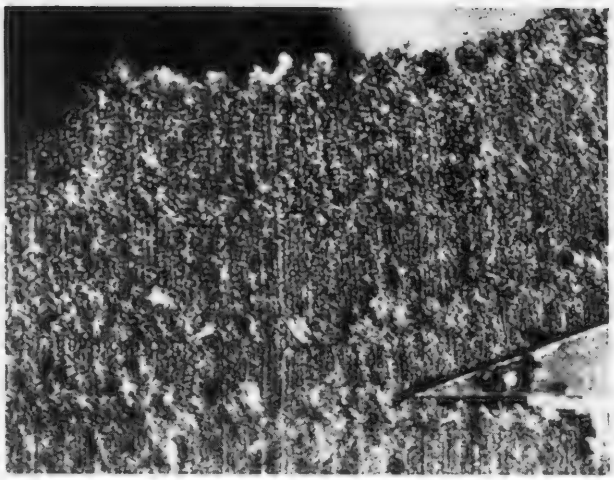

Fig. 20.—Type B veneer, showing development of continuous tension failure perpendicular to the cutting path.

Type A veneer is formed when cutting conditions are such that the wood splits ahead of the knife by shear and compression until failure of the split portion occurs in bending as a cantilever beam, as shown in Fig. 19.

Type B veneer occurs when tool forces cause continuous tension failures in a direction perpendicular to the cutting path, as indicated in Fig. 20.

Formation of Type A Veneer: Type A veneer appears to be produced through a cyclic series of events. At the start of the cycle, the knife advances to the work edge and produces localized areas stressed in tension in a direction perpendicular to the cutting path (Fig. 21). Continued movement of the knife relative to the work strains the wood ahead of the tool, produces failure in tension perpendicular to the grain at the knife edge, and induces stress in compression perpendicular to the grain and rolling shear acting in a plane parallel to the cutting path. A sudden splitting failure occurs ahead of the knife edge when the ultimate strength of the wood in rolling shear has been exceeded. As the knife advances, the split portion is deflected up the face of the knife and is stressed in bending as a cantilever beam. As bending progresses, stresses become critical and failure occurs as a cantilever beam at the point of maximum moment (Fig. 21). Continued movement of the knife relative to the work may produce additional deflection and accentuate the failure until the cutting edge contacts the point of bending failure and initiates the start of another cycle. Repetition of the above series of events produces veneer that contains severe lathe checks and rough surface characteristics.

Maximum tensile stresses develop at the point of maximum moment of the cantilever beam. Thus, the location of the ultimate check with respect to subsequent cycles is clearly dependent upon the length of the split. The length of the splitting failure appears to be determined by the strength of the wood in rolling shear and compression perpendicular to the grain.

The magnitude of tensile stress that a wood may sustain before failure through bending determines, in part, the depth of check penetration. The depth of check penetration may, as previously discussed, be increased by additional deformation after bending failure has occurred.

Several factors appear conducive to formation of Type A veneer. In the work, low resistance in compression perpendicular to the grain and rolling shear when accompanied by relatively high tensile strength perpendicular to the cutting path favor development of the splitting failures and ruptures due to accompanying bending stresses. From the geometry of veneer-cutting, it can be shown that a low coefficient of friction at the interface of the knife and the work as well as tool force distributions attending the large cutting angle are also contributing factors.

Type B Veneer Formation: Veneering conditions may, within a limited range, favor the development of a continuous tension failure that extends in a plane parallel to the cutting path. In the formation of Type B veneer, relative movement of the knife along the cutting path strains the wood ahead of the tool in tension perpendicular to the grain (Fig. 22). Continued advancement of the knife produces failure in tension at the knife edge and induces compression and rolling shear stresses parallel to the cutting path. The induced stresses are not exceeded in ultimate strength, however, and the splitting failure associated with Type A veneer does not develop. Deformation resulting from additional movement of the knife induces tensile stress perpendicular to the cutting path which ultimately exceeds the strength of the wood in tension perpendicular to the grain. Thus, wood failure more closely approximates a continuous peeling action.

The continuous, uniform process of wood failure described above results in veneer that contains no lathe checks and is of superior surface characteristics. Type B veneer, therefore, represents the ideal veneer from the standpoint of quality.

The production of Type B veneer appears to be a balance between force relationships and mechanical properties. Factors contributing to formation of Type B veneer include the following: 1) relatively low strength in tension perpendicular to the grain as compared with strength in compression perpendicular to the grain and rolling

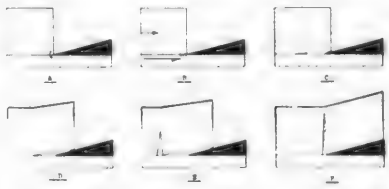

Fig. 21.—Sketch showing development of type A veneer. A, initial contact of the knife; B, straining of the wood at instant before failure; C, splitting of wood ahead of cutting edge; D, bending as a cantilever beam; E, failure as a cantilever beam; and F, accentuation of bending failure.

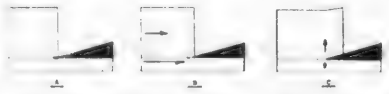

Fig. 22.—Sketch showing development of type B veneer. A, initial contact of the knife; B, straining of the wood at instant before failure; C, peeling of wood ahead of the knife.

shear, and 2) high coefficient of friction between the knife face and the work.

The significance of force relationships within the veneer particle, as influenced by the presence or absence of nosebar pressure, will be discussed in subsequent paragraphs.

Discussion of Mechanics of Veneer Formation

An exact theoretical stress analysis of the veneering process is confounded by complex stress distributions and the anisotropic nature of wood. An approximate solution, however, can be developed that is in reasonable agreement with observational data of veneer types, mechanical properties, and quality determinations.

Nosebar Pressure Absent: Although the use of nosebar pressure is accepted practice, it is felt that pressure may be completely relieved during the veneering process through 1) changes in the veneer thickness resulting from surface irregularities, or 2) deflection in mechanical elements of the lathe.

If the undeformed veneer is considered to be a particle held in mechanical equilibrium, Fig. 23 approximates the force relationships existing when no nosebar pressure is applied. The advancing knife exerts a resultant force R_K on the undeformed particle. This resultant force may be resolved into a horizontal component K_p and a vertical component K_n. K_p is resisted by a compressive force F_c acting over area w t of the undeformed particle and a rolling shear force F_s acting in the plane of the cutting edge. The forces F_s and K_n tend to rotate the undeformed particle, and are resisted by internal moment M that originates in the work. This resisting moment may be considered to develop through bending of the particle as a cantilever beam and from tensile stresses distributed along the lower surface of the particle in a direction normal to the cutting path. The magnitude of these resisting forces are determined by the amount of bending present in the particle.

The force relationships described above favor the production of Type A veneer. Woods with relatively high strength in tension perpendicular to the grain appear to fail in compression and shear before the ultimate strength in tension can be exceeded. Thus, the characteristic splitting failure occurs, which ultimately results in a lathe check.

Strength properties within the undeformed particle may be such as to result in Type B veneer, even though no nosebar pressure is applied to the particle. If the limiting stress in tension perpendicular to the grain is low with respect to strength in compression and rolling shear, conditions are favorable to a continuous tension failure in a plane parallel to the cutting path. The forces applied to the particle by the knife produce failure in tension before the limiting compressive and shear values can be exceeded, and the peeling action previously described as producing Type B veneer results.

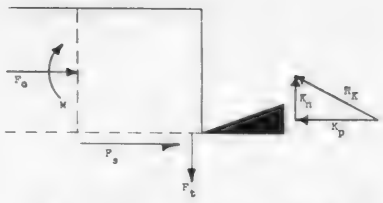

Fig. 23.—Force system suggested for discussion of mechanics of veneer-cutting. Nosebar pressure absent.

Nosebar Pressure Present: Fig. 24 approximates the force relationships that exist in the undeformed veneer particle when the effects of nosebar pressure are taken into consideration. As in the absence of nosebar pressure, the advancing knife exerts resultant force R_K on the undeformed particle, and is resolved in horizontal and vertical components K_p and K_n. The nosebar exerts resultant force R_N to the particle, and is resolved into horizontal and vertical components N_p and N_n. The force components K_p and N_p are resisted by compressive force F_{cp} and shearing force F_s. The component N_n is resisted by compressive force F_{cn}, while force K_n is resisted by tensile force F_t.

Non-colinearity of the horizontal and vertical force components of the knife and nosebar tends to rotate the particle under consideration, and thereby creates compressive stresses at the upper surface of the particle and large tensile stresses perpendicular to the cutting path near the knife edge. In response to these stresses, the particle is initially strained so that bending stresses resulting from deflection of the veneer by the knife are minimized. The above force relationships favor the production of Type B veneer.

Without nosebar pressure, tensile strength perpendicular to the grain often cannot be sufficiently reduced by temperature adjustment to produce the desired continuous tension failure and production of Type B veneer. The application of nosebar pressure to the particle, however, creates sufficient initial tensile stress so that the additional stress resulting from the advancing knife exceeds the ultimate strength of the wood in tension perpendicular to the grain, thus producing the desired peeling action.

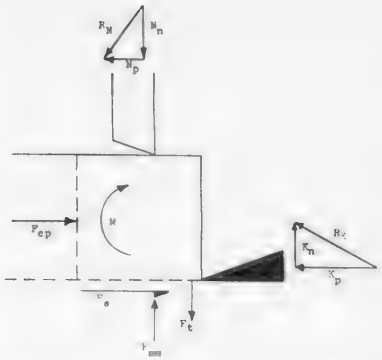

Fig. 24.—Force system suggested for discussion of mechanics of veneer-cutting. Nosebar pressure present.

The amount of nosebar pressure required to create sufficient tensile stress for production of Type B veneer appears to be a balance between force relationships and mechanical strength. If the limiting strength of the material in tension perpendicular to the grain does not approach or fall below the limiting strength in rolling shear and compression, additional nosebar pressure is required to produce the desired tensile stress in the veneer particle. If nosebar pressure is insufficient or if tensile strength is high relative to the strength in rolling shear and compression, Type A veneer will be produced. Thus, with the application of controlled nosebar pressure, the occurrence of lathe checks may be reduced or eliminated.

As previously stated, high frictional forces appear to favor the production of Type B veneer. From the geometry of cutting, it can be shown that large frictional forces at the interface of the knife and the wood have the net effect of reducing tensile stresses resulting from bending.

Application of Visual Observations and Theoretical Analysis to Quality and Mechanical Properties Data

Comparison of Tables 1 through 3 show that, as machining conditions approach those required for production of Type B veneer, the severity of checking and surface roughness are reduced. It will be noted that, although severity of checking is reduced by the application of nosebar pressure, the formation of Type B veneer requires that tensile strength of the material be low as compared to compressive and shearing strength.

Table 1 indicates the sapwood of yellow birch to have slightly superior veneering characteristics when veneered below 200° F. Figs. 15 and 16 show that tensile strength as compared to shearing and compressive strength is more favorable for production of Type

B veneer in the sapwood. In addition, it has been shown that the sapwood is tougher than the heartwood (12).

When yellow birch was machined at 200° F., the depth of check penetration was observed to be shallower in the heartwood than in the sapwood. At 200° F., the relative strength properties conducive to formation of Type A veneer are slightly in favor of the sapwood. However, coefficient of friction data (Fig. 18) suggest that at approximately 180° F. frictional forces exerted on the heartwood become greater than those on the sapwood and thus reflect the improved heartwood veneer quality.

Table 3 shows that redwood contained no checks when machined at 160° F. and 200° F., regardless of the nosebar opening used. Fig. 17 reveals that at approximately 160° F. the tensile strength, as compared to the compressive and shearing strengths, approaches the conditions favorable for formation of Type B veneer. In addition, Fig. 18 indicates that high frictional forces are imposed on the veneer particle.

Conclusions

The research summarized above suggests a number of conclusions regarding the veneer-cutting process.

1. The veneer-cutting process is characterized by two extreme types of veneer formation: 1) veneer formed by a splitting and bending process and containing severe lathe checks and rough surface qualities, and 2) veneer formed by a peeling process and characterized by the absence of lathe checks and superior surface qualities.

2. The quality of veneer formed under a given set of veneering conditions is determined by the nature of wood failure ahead of the knife.

3. The surface quality generated is a function of wood failure.

4. The type of wood failure, and hence veneer quality, is a function of wood properties and force relationships within the veneer particle.

5. Mechanical properties define the nature of wood failure under a given force system.

6. Nosebar pressure influences veneer quality by establishing additional forces within the veneer particle.

7. Frictional forces at the knife face are important because they affect force relationships within the veneer particle.

8. Wood mechanical properties that appear to have the most significant effect on veneer quality are: compression perpendicular to the grain, tension perpendicular to the grain, and rolling shear.

9. For the woods tested, tension perpendicular to the grain is reduced more than compression perpendicular to the grain and rolling shear with an increase in temperature.

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Specialized Plywood Pressing Equipment[1]

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This paper describes the adaptation of standard plywood pressing equipment to specialized needs, and includes details of construction and operation. The installation of this equipment covers over two years of engineering effort to develop facilities that would practically cover a wide range of laminating possibilities.

SETTER BROS. INC. has for many years been a manufacturer of specialty wood products, starting before 1900 with a basswood engraving block and successively adding such items as cherry electrotype blocking, maple veneer and plywood specialties, architectural-grade hardwood plywood, metal to plywood laminates, and even paper lollipop sticks, an outgrowth of maple meat skewers and candy sticks.

Approximately two and a half years ago, the firm began an extensive renovation of their hardwood plywood manufacturing facilities, and it is with this endeavor and specifically with the pressing equipment that this paper is concerned.

Three principal problems faced the company in choosing the necessary pressing equipment for their specialized requirements:

1. How best to serve the requirements of many long-time customers whose end use was such as to demand plywood made in a conventional cold press with perhaps vegetable, casein, or even resorcinol adhesives.

2. How best to equip for reasonable hot pressing capacity that would incorporate the necessary versatility of operation needed in the production of architectural plywood requirements.

3. How best to answer the small but vitally necessary requirement for large panels that are a part of most architectural orders, and at the same time achieve the versatility to permit the use of either hot- or cold-setting adhesives including the possibility of curved sections.

Size and Range of Presses

The first problem resolved into two major questions, namely, how large should the press be and what should be the range of pressure. It was obvious that a conventional cold press would satisfy the need and, as later reasoning will indicate, a press with a platen area of 50 by 100 inches was considered adequate.

The press chosen was a Merritt–Solem, 5-ram, side-opening, upward-acting unit capable of a maximum of 300 psi over 5000 square inches of platen area. The press has 50 inches of daylight with a ram travel of 30 inches, which permits the pressing of small bales without the necessity of filler beams.

Two features of the press are somewhat unconventional. The first is a simple valve arrangement whereby the rams can be used in multiples of 1, 3 and 5 to permit the pressing of small panels at high pressure without undue stresses occurring in the press bolster. In fact, panels as small as 12 by 28 inches may be pressed at as low a pressure as 50 psi with one ram. As a protection against operator carelessness or neglect, the rams under pressure are indicated by monitor lights on the control panel and, in addition, a pair of sensitive Micro-Switches mounted on a deflection bar under the bolster will automatically shut off the press if undue deflection occurs. Inasmuch as many different sizes and constructions of panels may be pressed in a single working day, this feature has been found to be invaluable, and the change from one setup to another requires so little time as to be negligible.

The second feature incorporates the use of four heavy gear racks, one attached to each corner of the press bolster, for stabilizing the movement of the bolster as pressing takes place. The racks on each side are geared to a common shaft whose journals are attached to the base of the press. Thus, as the bolster moves up and down, there is no tendency for one ram to move ahead of another. Not only does this prevent unnecessary ram wear, but, more important, it has proven to be a very practical method of minimizing slippage in the bales.

An interesting sidelight concerning this press developed recently when it was found necessary to bond several

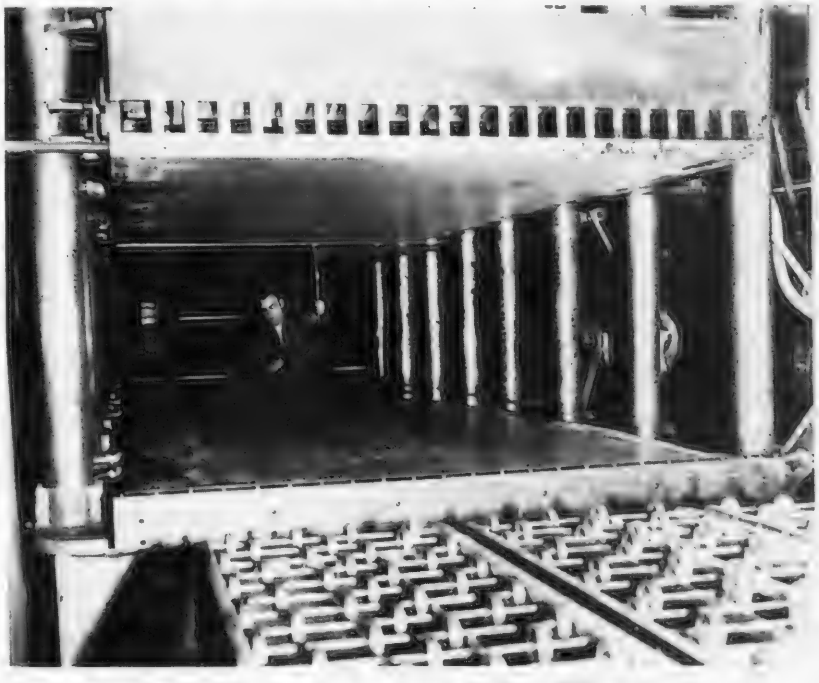

Fig. 1.—View through platen area of 66- by 200-inch press.

[1] Presented at Session III, Veneer and Plywood, of the Eleventh National Meeting of the FPRS, June 23–28, 1957, in Buffalo, New York.

The Author: E. D. Cottrell spent 2 years at Culver Military Academy and 3 at the University of Rochester before joining Setter Bros. in 1939. He has served as plant engineer of the company since 1946, was elected a director in 1952, and vice-president in 1953.

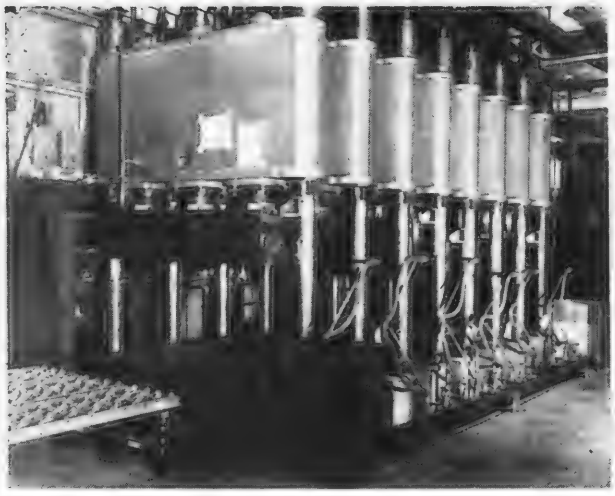

Fig. 2.—Side view of the 66- by 200-inch press.

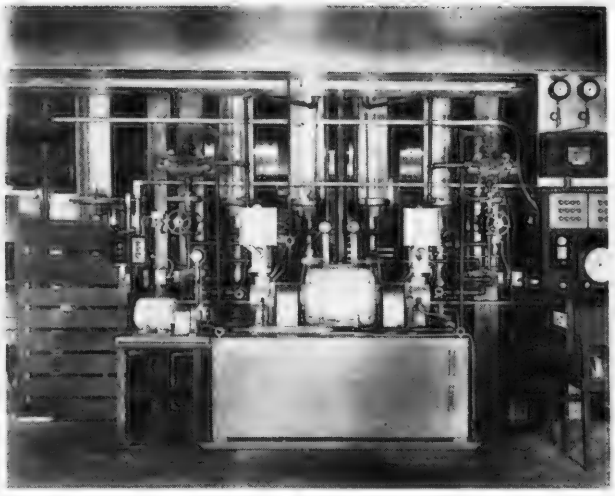

Fig. 3.—Side view of the 66- by 200-inch press, showing the hydraulic system and controls.

panels over seven feet square. The addition of a small heat exchanger to the hydraulic circuit permitted overnight operation of the press so that, by extending the retaining beams to cover the overhang of the panels on each side of the press, and by using regular retaining clamps, it was possible to make these particular panels with very satisfactory results.

Size and Capacity

The second problem, which involved a multiple-opening hot plate press, was a matter first of size and capacity. After a careful review of past records of the Company's production of hardwood plywood, particularly architectural grade, it was decided that a press capable of producing panels 4 by 10 feet would satisfy the majority requirements.

The press purchased was a Williams–White upward-acting, 5-opening, 4-inch daylight, side-opening, 8-ram unit capable of a maximum of 300 psi over a platen area of 54 by 128 inches and with a maximum of 0.006-inch combined deflection of the head and platen at full pressure. The minimum size of panel, as dictated by the placement of the rams and the pressure control, is 12 by 60 inches at 150 psi. The press was supplied with dual pressure and timing controls to permit operation of the press at two different pressures during a single cycle; an effective guard against steam blows under certain conditions. This press is conventional in all respects with the exception of certain modifications made during and after installation, and detailed as follows:

In considering the high initial cost of the steam platens and their vulnerability to damage by surface abrasion, dents, and so forth, it was deemed advisable to provide them with some sort of protection. Each working surface of each platen is covered with a single sheet of 11-gauge, stretcher-leveled, cold-rolled steel, which is tack welded to a machined tensioning bar running the full length of each long edge of each platen. After the sheets are welded, tension is applied by tightening set screws, which are tapped into the tensioning bar and bear against the edges of the platen. A simple formed nosepiece is then lightly welded in place to facilitate the loading and unloading of the press. When these sheets eventually need replacement, the operation can be done at a fraction of the cost of resurfacing the platens and with a very minimum of down time. And, of course, the full thickness of the platens is maintained.

The production of architectural hardwood plywood often presents the problem of pressing perhaps only one panel of a size, and, even though most of the panels required for a particular job may be of reasonable dimensions, that one panel may be quite small. To achieve this flexibility, the press can be quickly converted to use the four center rams only. Since the jack rams are placed at the extreme ends of the bolster, it was found necessary to eliminate the jack rams from the high-pressure circuit to prevent possible excessive deflection of the bolster when pressing very small panels.

An ever present worry in the manufacture of an architectural plywood is the possibility of irreparable damage occurring to one panel that, because of the careful sequence matching, may be literally impossible to replace. Such a thing can occur accidentally in any of the operations during manufacture, but the actual pressing seems to be by far the most vulnerable spot, and the loss of a press load could amount to almost a catastrophe. While power failures are fortunately infrequent, they do occur and often at the most inopportune moments. The addition of a normally closed solenoid valve and an emergency hand-operated hydraulic circuit guards against loss from such a cause.

The control of temperature in a long, open side platen presents some difficulties that can be tough to solve economically. An oversize series of flexible bracket tubes assures an adequate supply of steam to the inlets of each platen, and the drain outlets of the platen are equipped with individual strainers and traps. The particular platens on this press were drilled and plugged to give two separate serpentine passages in each platen, each covering one-half the platen. Since there are six platens involved, this meant 12 separate inlet and 12 separate outlet connections. Metered flow tests were conducted at various pressures through each serpentine to determine if different resistances would be encountered. While the results of these tests were substantially negative, experience proved that, to achieve uniform heating, it was necessary to equip each serpentine inlet with an adjustable needle valve to properly balance the flow of steam. The final balancing was achieved with the use of a surface pyrometer. Periodic checks have shown that very little change has taken place. As a further precaution, a relatively inexpensive thermistor monitoring system has been installed with two check points on each platen. The monitoring is continuous, and responds to a drop in temperature of less than 5° F. It is also self-adjusting for different temperature settings of the control system.

Versatile Press

The solution of the third problem, that of providing a large versatile press, required many hours of investi-

gation and planning before the most satisfactory and economical answer was arrived at. A thorough investigation was made, covering many manufacturers, both foreign and domestic, in the hopes that the press could be secured within the realm of reasonable cost. In every case, however, it was found that, while the basic unit could be secured at a reasonable figure, the addition of the special features raised the price to a prohibitive level. It was decided, therefore, that a press could be designed to incorporate these features, and the components could be purchased and prefabricated as required. All parts would then be shipped to Setter Bros. Inc. and the final assembly and erection would be done on a prepared foundation. This plan was followed and resulted in a press with unusual flexibility of operation, and, most important, a saving of many thousands of dollars.

The greatest responsibilities, those of design, engineering, and procurement of parts were carried out by Ericsson Merritt, Inc., while the final assembly and erection was carried out by the regular maintenance personnel of Setter Bros. Inc. Substantial savings were realized because many of the small components could be fabricated in the Company machine shop. All the fitting and welding of the hydraulic piping, steam and drain piping, and so forth, was done by the Company personnel at the time of erection.

The press itself is a single-end opening, downward-acting press with a maximum daylight of 30 inches and a maximum platen area of 66 by 200 inches. There is 72-inch clearance between the strain rods, of which there are eight on each side of the press. A maximum pressure of 250 psi can be secured over the entire platen area, and the construction is sufficiently heavy to permit 300 psi on an area 50 by 200 inches with a combined head and platen deflection not exceeding 0.006 inch. A view through the press as shown in Fig. 1, and a side view as shown in Fig. 2 will give an indication of the size of the unit.

The lower platen of the press is one piece, while the upper platen is in two parts fitted at the center with a removable steel spline, which permits the press to be operated as a single unit or as two units, each capable of pressing a panel 66 by 100 inches. Since the platens are in reality steam platens, the press may be operated as either a cold or a hot press as desired, and the 30 inches of daylight permits the cold pressing of a number of panels. The amount of daylight can be quickly set to provide a minimum opening for hot pressing, and it can be seen that the maximum daylight will allow the use of forms as may be required for the curved sections that are sometimes a part of an architectural specification.

The hydraulic system of this press was designed to give as much flexibility as possible in the range and pattern of pressure. Two hydraulic pumps were used coupled to a single electric motor to allow the two halves of the press to operate independently of each other, each half being operated by its own control and timing station. The changeover from dual to single operation is readily accomplished at the main control panel by means of key-operated switches that also permit the timers to be locked out of operation for long holding cycles. Inasmuch as only a very small volume of oil is required to maintain the press at operating pressure, a third small pump and motor were supplied for use exclusively on long holding cycles, thus allowing the large motor and pumps to be shut down. Fig. 3 is a photograph of the control side of the press, and illustrates the general arrangement of the hydraulic and control components. It may appear to be rather complex, but the actual operation is relatively easy to master.

Fig. 4.—A 60- by 192-inch walnut-faced panel produced in the large press. The panel was finished to a high gloss, which accounts for the reflection streaks in the photo.

The versatility of this press can be shown by the fact that it can be quickly arranged to handle a panel 66 by 200 inches at 250 psi or a panel 12 by 50 inches at 75 psi. Fig. 4 is a photograph that tells the story better than words. Such versatility is a combination of both pressure and cylinder controls. The press is equipped with 24 hydraulic cylinders, each of which is monitored by means of an individual pressure switch to a central indicator light panel on the main control board. The pattern of cylinders used for any particular size is thus indicated to the operator. Each cylinder is controlled by two small hand valves that project into the second story of the plant. By opening one valve and closing the other or vice versa, a cylinder can be placed under or released from pressure. The valve handles are color coded to eliminate possible confusion, and not more than 3 to 4 minutes are required to change from any one pressure pattern to another.

It can be appreciated that a downward-acting press requires no high-volume pump to give a rapid closing speed, since gravity does the work. Therefore, it was found that a relatively small pump would do the job, and, in the interest of economy, the pumps selected have an upper pressure limit of 1000 psi. To achieve the 2500 psi plus needed for the maximum press capacity, a 3-to-1 hydraulic booster was installed in the circuit from each pump. A single valve renders the booster operative or inoperative as the occasion may demand, with the result that a very wide range from minimum psi is obtainable. It can thus be seen that the press can be used at very low ranges, which permits the bonding of such materials as honeycomb where the conventional press has far too much pressure, even at its lowest setting.

Accurate Temperature Control

The temperature control of this large press has been found to be surprisingly accurate, which is attributed to two principal factors. First, the platens are each drilled and ported to have 6 separate serpentines in the 200 inches of length. Each is connected to a common manifold through flexible bracket tubes at the inlet side, and is trapped separately on the drain side, which insures even distribution of steam and excellent sensitivity to load variations. Secondly, and this is a feature also incorporated on the other hot press, a manually adjustable, air-actuated, pressure-reducing valve was installed in the steam supply line. Because it allows the maintenance of the proper relationship between the

line pressure and the platen temperature desired, it serves to even out the control and give a very uniform flow of steam to all parts of the platen.

It can be seen from the brief description of the steam control systems on these two hot-plate presses that the problem of accurate control of temperature is not an easy one. Furthermore, each pressing unit presents its own individual peculiarities. It is felt, however, that the uniform heating of any pressing platen will be improved by following these general suggestions:

1. Keep the length of each serpentine as short as practicable.

2. Be sure that the main steam manifold and individual bracket tubes to the inlet of each serpentine are of adequate sizes.

3. Trap each serpentine individually and provide a means of by-passing the traps for quick warm-up.

4. Provide a means of balancing the flow of steam to each serpentine, if required.

5. Install an easily regulated pressure-reducing valve to help even out the flow of steam at a given temperature setting of the control system.

The two hot presses described are located close to each other in the plant, which allows the installation of a single heat exchanger, pump and accessory units to serve them both with circulating hot water as a heating medium for use at temperatures near or below 220° F. The control of temperature in this low range becomes very erratic, if not impossible, when steam is used, whereas the use of hot water gives almost pinpoint control. Each connection from each serpentine of each platen is so valved as to divert the flow from the serpentine through an adjustable flow-control valve when the press is used with hot water. The adjustment of these flow-control valves assures a balanced system whereby each serpentine receives its proportionate share of the total flow. The steam supplying the heat exchanger can be furnished through the control system of either press, which eliminates the necessity for elaborate independent controls and requires only the operation of a few valves.

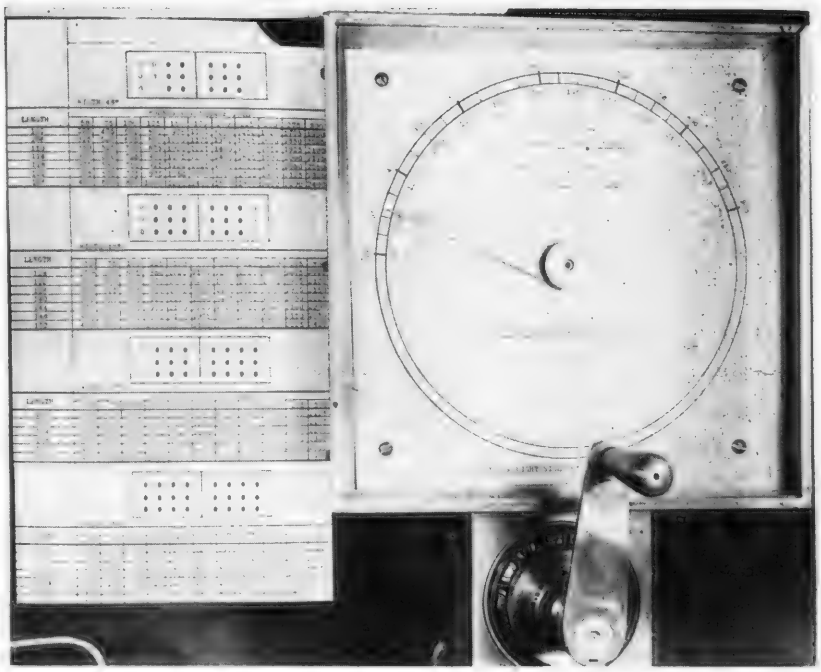

Fig. 5.—Pressure-control chart and table for the 66- by 200-inch press.

Presetting Hydraulic Circuit Pressures

One problem common to all three presses had to be solved finally to achieve the easy and quick versatility required. That was being able to preset the hydraulic circuit pressures. Where a press is producing one size of panel for perhaps weeks at a time, this problem does not exist because the conventional controls are adequate. When the pressure of the circuit is to be changed several times daily, however, the importance of accurately presetting the pressure quickly and repetitively becomes paramount. To answer this problem, the pressure-control valve on each press was redesigned as required to permit the mounting of an adjusting handle, which in turn was geared to a pointer. The press was then taken repeatedly through its entire pressure range to develop a calibrated chart that was then reproduced and permanently mounted. Experience has shown that the repetitive accuracy is excellent, and is consistent with the master pressure gauges at all times.

Considerable discussion evolved around the question of providing the press operator with a quick means of calculating just what the system pressure should be for any particular size of panel. It was finally agreed to provide a set of small tables to which he could easily refer. Fig. 5 is a photograph showing a typical table for the 66- by 200-inch press, together with the adjusting handle and calibrated chart for the pressure control. It should be noted that this reference table indicates not only the pressure setting for width, length and psi desired, but also the cylinder pattern to be used.

Conclusion

The installation of this specialized pressing equipment as described above has been a most stimulating and rewarding experience for the Setter Bros., who sincerely believe that there is great opportunity for the small manufacturer to solve the challenging problems of modernization economically. It is hoped that the information given concerning these problems and their solution may in some measure be of help to others in the field.

Blister- and Stain-Resistant Paints[1]

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Although none of the paint systems tested were completely satisfactory, the alkyd blister- and stain-resistant paint used as the original coating on new wood is outstanding in performance when repainted with acrylic, polyvinyl acetate, oil, or alkyd type coatings.

PAINTS THAT ARE RESISTANT to blistering and staining are made from special vehicles pigmented with titanium dioxide and selected extender.[2] Alkaline constituents are eliminated from the pigmentation to maintain a low pH in the film in order to resist staining from either iron, copper, or both. These same coatings applied to new wood and subjected to adverse moisture conditions show exceptional blister resistance. Compositional information on a typical experimental blister- and stain-resistant, tint-base paint is shown in Table 1.

The purpose of this paper is to review recent exposure results obtained in connection with the further evaluation of blister- and stain-resistant coatings. The subjects to be considered include:

1. Repaint characteristics of various coatings as tested on new wood where moisture conditions are severe.

2. Blistering and adhesion characteristics of selected coatings applied to wood panels from which an aged, conventional, oil-type house paint film has been removed by the usual burning procedure.

3. Exposure characteristics as evaluated on test fence panels and on house tests of blister- and stain-resistant paints in comparison with conventional house paints.

It should be understood that the data and illustrations given in this paper are experimental in character, and are therefore subject to change as additional information becomes available.

Table 1.—EXPERIMENTAL BLISTER- AND STAIN-RESISTANT PAINT* (TINT BASE)

	Pounds	Gallons
Chalk-resistant rutile titanium dioxide	200	5.72
Magnesium silicate	353	14.86
Long-oil Alkyd (100% solids)	400	47.92
24% Lead Naphthenate	10	1.04
6% Cobalt Naphthenate	2	0.25
10% Phenyl mercury oleate solution	23	3.38
Mineral spirits	174	26.83
	1162	100.00

*Per cent PVC, 30; consistency (K.U.), 70.

Repaint Characteristics

New Wood: Four systems (as follows) were applied as repaints over previously painted, edge-grain white panels:

Repaint System	Type
Conventional house paint (OHP) over zinc-less primer	Oil
Blister and stain resistant paint	Alkyd
Acrylic emulsion paint	Acrylic
Polyvinyl acetate emulsion paint	PVA

Pertinent compositional details on the particular paint systems used in these tests are given in Table 2. It should be realized that the exposure results presented in the text refer to the paint systems as such, and not to any particular vehicle or pigmentation.

To prepare the panels for test, two coats of the original paint systems were applied to the new wood panels in June. The panels were exposed in Delaware at a 45-degree angle from the vertical, facing South, for three months. Two coats of the four repaint systems tested were applied in September. The panels were re-exposed at 45 degrees facing South for two months, and then were placed on the blister-test house.

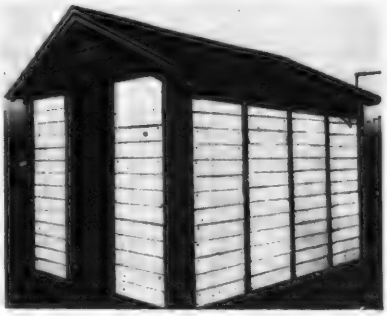


Fig. 1.—The blister-test house.

The appearance of the blister-test house is shown in Fig. 1. As described by Lilley,[3] the wall structure from inside to outside includes perforated transite, studs, sheathing, and test panels. Conditions inside the blister-test house were adjusted to 75° F. and 70 per cent relative humidity on December 1st. A severe moisture condition developed rapidly in the test panels as judged by an electronic moisture meter. After eleven weeks of exposure, ratings were made for blistering according to the system described in Table 3.

The adhesion test was conducted by making eleven cuts simultaneously, approximately 1.4 millimeters apart. The cuts were made with razor blades at a 45 degree angle to the grain of the wood and then at right angles to the original cuts to form 100 squares. This area was rubbed lightly with a cloth to remove all portions of the film that were not adhering to the wood.

The gradings used were identical to those for blistering, except that "Per cent of Area Blistered" was replaced

Table 3.—GRADING SYSTEM FOR BLISTER RESISTANCE

Per cent of area blistered	Visual rating	Blister resistance	Numerical rating
0	None	Perfect	10
1	Very slight	Excellent	9
4	Slight	Good	8
9			7
16	Considerable	Fair	6
25			5
36	Bad	Poor	4
49			3
64	Very bad	Very poor	2
81			1
100	Complete	None	0

Table 2.—COMPOSITION OF PAINTS

No.	Pigments*	Pounds per gallon	Vehicle	Pigment volume, per cent
1	TiO_2(FCA/CRR)/ZnO/Mg Sil.	1.46/0.37/2.76/2.41	75/25-AR/XLO	27.4
2	TiO_2-FCA/Mg Sil.	2.00/3.56	Long-oil alkyd	30.0
3	TiO_2(FCA/CRR)/Mica	0.26/2.33/0.29	PVAc/DBP emulsion	27.0
4	TiO_2(FCA/CRR)/Mg Sil.	0.50/2.00/0.97	Acrylic emulsion	25.0
Primer	TiO_2-CRR/BCWL/BSWL/Mg Sil.	1.15/2.25/2.25/3.35	47/53-Raw/Z-2 LO	35.0

*TiO_2: FCA—free-chalking anatase; CRR—chalk-resistant rutile.

[1] Presented at Session IV, Wood Finishing, of the Eleventh National Meeting of the FPRS, held June 23–28, Buffalo, New York.

[2] Vannoy, W. G. Amer. Paint Jour. 36-(32):82. Apr. 1952.

[3] Lilley, F. A., Paint Industry Mag. 71(3):15. March, 1956.

The Author: Wesley Vannoy received his BS degree in chemistry from Coe College, and followed with a Ph.D. in physical chemistry from Cornell University. He joined Du Pont as a research chemist in 1927, and worked in the Fabrics and Finishes and Chemical Departments. He is now in the Sales Service Division of the Pigments Department.

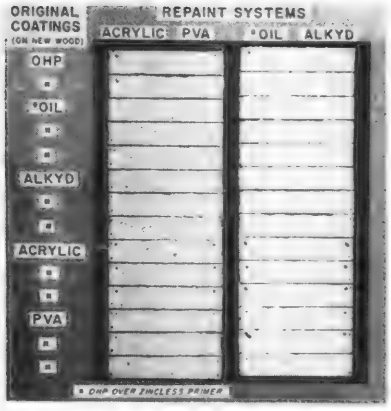


Fig. 2.—Results of repaint tests on the blister-test house. East exposure for 11 weeks.

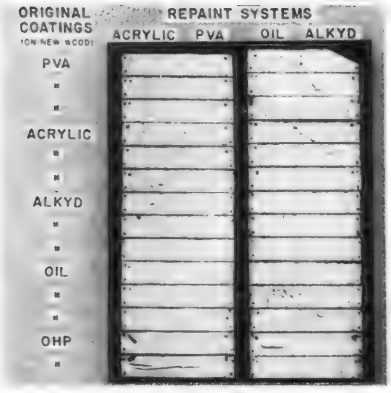


Fig. 3.—Results of repaint tests on the blister-test house. West exposure for 11 weeks.

by "Per cent of Film Removed" in the two square centimeter area tested.

The application of each of the four repaint systems over conventional house paint resulted in very bad blistering and practically complete loss of adhesion, regardless of the repaint system used. The average ratings obtained for each repaint system are recorded in Table 4.

Repainting with the same paint originally used on the panels, as shown in Table 5, gave essentially no blistering and excellent adhesion for the alkyd paint. The polyvinyl acetate emulsion paint showed no blistering but only fair adhesion, while the conventional house paint over zincless primer and the acrylic emulsion paint gave slight blistering and very poor adhesion.

Acrylic, PVA, oil, and alkyd coatings applied over each of the four repaint systems originally applied to new wood gave average performance ratings for blistering and adhesion, as shown in Table 6. Again, the alkyd paint used as the original coating was outstanding in performance. It showed essentially no blistering and excellent adhesion, regardless of the repaint system used. The polyvinyl acetate emulsion paint showed better blister resistance and adhesion to wet wood than did the acrylic emulsion paint. Further, the lower average gradings for the original emulsion coatings in Table 6 as compared with Table 5 resulted from blistering and adhesion caused by repainting the emulsion paints with the less permeable oil or alkyd coatings.

The repaint tests are illustrated in Fig. 2 for the East exposure and Fig. 3 for the West exposure. In going from the East to the West exposures, the panels were reversed and inverted to compensate for possible differences resulting from the location on the blister-test house.

The illustrations and exposure data presented point to the blister- and stain-resistant paint as having exceptional merit for application to previously unpainted wood surfaces.

Table 4.—RATING* OF REPAINT SYSTEMS† ON BLISTER HOUSE FOR 11 WEEKS

	Blistering	Adhesion
OHP over zincless primer	4	0
Alkyd blister- and stain-resistant paint	5	0
Acrylic emulsion paint	4	0
Polyvinyl acetate emulsion paint	4	0

*Average ratings of 4 panels for each repaint system.
†Original coating on new wood—convention house paint (OHP).

Table 5.—RATING* OF SELF REPAINTS† ON BLISTER HOUSE FOR 11 WEEKS

Original and repaint coatings	Blistering	Adhesion
OHP over zincless primer	8	2
Alkyd blister- and stain-resistant paint	10-	10
Pervlic emulsion paint	7	2
Aolyvinyl acetate emulsion paint	10	5

*Average ratings of 6 panels for each system.
†Original coatings on new wood.

Table 6.—RATING* OF ACRYLIC, PVA, OIL, AND ALKYD REPAINTS† ON BLISTER HOUSE FOR 11 WEEKS

Original coatings	Blistering	Adhesion
OHP over zincless primer	8	2
Alkyd blister- and stain-resistant paint	10-	10
Acrylic emulsion paint	6	1
Polyvinyl acetate emulsion paint	8	4

†The original coatings on new wood were each repainted with acrylic, PVA, oil and alkyd type paints.
*Average ratings of 24 panels, including six panels from each of the four repaint systems.

Table 7.—RATING* OF REPAINTS† OVER BURNED-OFF WOOD

Repaint coatings	Blistering	Adhesion
Acrylic emulsion paint	9	3
Polyvinyl acetate emulsion paint	9	3
OHP over zincless primer	2	0
Alkyd blister- and stain-resistant paint	3	0

*Average ratings of 6 panels for each system.
†Original coating—conventional house paint (OHP), burned off.

"Burned-Off" Wood: To prepare the panels for test, two coats of conventional house paint were applied to new, edge-grain white pine panels in June. The panels were exposed at a 45-degree angle facing South for three months, after which the conventional house paint was burned off in the usual manner. It should be understood that the usual burning procedure does not completely remove all the original paint from the substrate. The repaint systems were then applied to the burned-off panels.

After two months of exposure at 45 degrees facing South, the panels were placed on the blister-test house. Ratings for blistering and adhesion, as obtained after eleven weeks of exposure to severe moisture conditions, are given in Table 7. These data show that, although the adhesion ratings were of a low order, the polyvinyl acetate and acrylic emulsion paints were essentially equal in performance and decidedly superior to the alkyd blister- and stain-resistant paint or to conventional house paint over zincless primer. These results are illustrated further in Fig. 4 and Fig. 5.

As discussed by Broeker,[4] essentially complete removal of the old paint is required before good performance

[4] Broeker, J. F., Paint Industry Mag. 70(7):9 July, 1955.

Fig. 4.—Results of repaint tests over burned-off wood on the blister-test house. South exposure for 11 weeks.

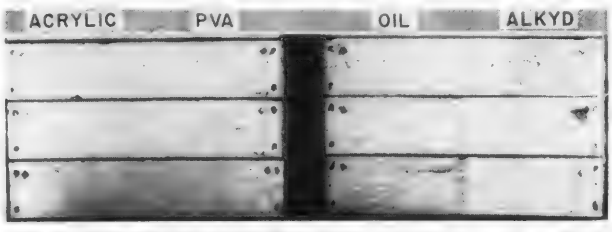


Fig. 5.—Results of repaint tests over burned-off wood on the blister-test house. North exposure for 11 weeks.

Table 8.—DURABILITY CHARACTERISTICS ON YELLOW PINE TEST FENCES EXPOSED AT A 45° ANGLE FACING SOUTH FOR FOUR YEARS IN DELAWARE

	Checking	Cracking	Erosion	Dirt and mold	General appearance
OHP over zincless primer	8	7	7	4	2
Alkyd—FCA* TiO_2	†	†	1	†	0
Alkyd—CCR† TiO_2	10	8	10	4	5
Alkyd—CRR§ TiO_2	10	10	10	5	6

*Free-chalking anastase TiO_2.
†Erosion; insufficient film to grade.
‡Chalk-resistant TiO_2.
§Fed. Spec. TT-T-425a Type III.

Table 9.—DURABILITY CHARACTERISTICS ON CEDAR TEST FENCES EXPOSED VERTICALLY FACING SOUTH FOR FOUR YEARS IN DELAWARE

	Checking	Cracking	Erosion	Dirt and mold	General appearance
OHP over zincless primer	10	10	10	8	7
Alkyd—FCA* TiO_2	10	9	9	6	6
Alkyd—CRR† TiO_2	10	10	10	7	7
Alkyd—CRR‡ TiO_2	10	10	10	6	7

*Free-chalking anastase TiO_2.
†Chalk-resistant TiO_2.
‡Fed. Spec. TT-T-425a Type III.

characteristics can be realized with the blister- and stain-resistant paint where moisture conditions are severe. Complete removal of the old paint involves burning in the usual manner, followed by sanding or scrubbing with a suitable paint remover. Any economical and effective means of completely removing old paint films would be helpful to encourage the use of blister- and stain-resistant coatings.

The emulsion paints offer interesting possibilities for use on new or burned-off wood substrates where moisture conditions are severe, because the high permeability of such films permits the escape of excess moisture. More exposure data and experience are needed, however, before this practice could be followed safely. Improved adhesion to chalky substrates, and also less softening and loss of adhesion from excess moisture, would be helpful in preventing costly failures with emulsion coatings.

Test Fence Exposures

The durability characteristics of a blister- and stain-resistant paint are changed markedly by the type of titanium dioxide used in the pigmentation. When tested on yellow pine at 45 degrees facing South, chalk-resistant rutile titanium dioxide imparted definitely better durability characteristics to the alkyd blister- and stain-resistant paint than did free-chalking anatase titanium dioxide, as shown by the data in Table 8. Further, after four years of exposure, the alkyd paint pigmented with chalk-resistant rutile was considerably superior in film integrity and general appearance to conventional house paint over zincless primer, which was used as a control for these exposures. There is evidence of a considerable to bad mold condition on these panels, however, which shows the need for a more effective preservative for such coatings. The actual appearance of these panels at four years is illustrated in Fig. 6.

Data for the corresponding South vertical exposures as tested on cedar are given in Table 9. Evidence of erosion is just beginning to show where free-chalking anatase titanium dioxide is used in the blister- and stain-resistant paint. Otherwise, the four-year performance differences are minor, as demonstrated in Fig. 7. Again, there is an indicated need for a better preservative to guard against mold growth.

House Tests

Performance comparisons on houses further demonstrates the excellent appearance and durability characteristics that can be realized with blister- and stain-resistant paints. It should be understood that the house-test illustrations used do not represent comparisons made in the presence of a severe moisture condition.

A two-year comparison of alkyd blister- and stain-resistant paint compared with conventional oil-type house paint is shown in Fig. 8. These coatings were applied as repaints over cedar shakes. As may be observed from the illustration, definite advantages in appearance and in resistance to staining from the copper gutter are evident for the alkyd paint.

The ultimate durability characteristics for buff tints of the alkyd blister- and stain-resistant paint, as compared with conventional oil-type house paint and lead in oil, are illustrated in Fig. 9. Tested as repaints over yellow pine for four years, the alkyd paint presented better appearance and less film failure than did the oil-type house paint or lead-in-oil coatings included in this comparison. Evidence of staining from the copper gutter can be observed on both oil-type paints, while such staining was not evident on the alkyd paint. Staining from the bronze window screen was much more in evidence on the lead-in-oil paint than on

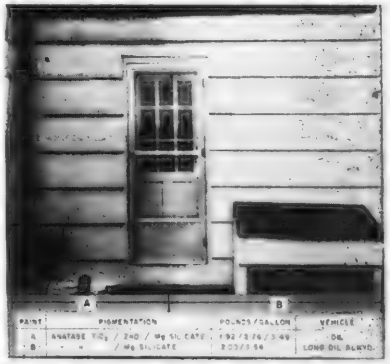


Fig. 8.—Alkyd blister- and stain-resistant paint (B) and conventional oil-type paint (A) after a 2-year northwest exposure. Darkness at left is staining from copper gutter.

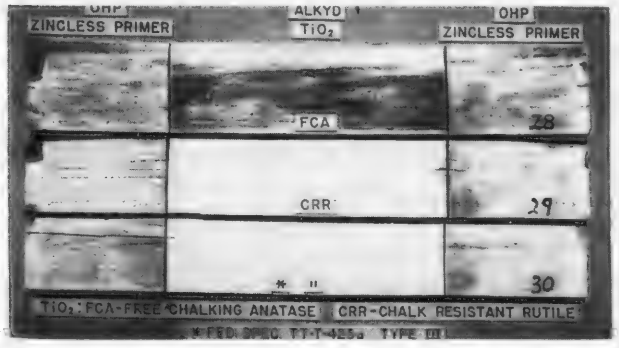


Fig. 6.—Comparison of type of TiO_2 pigment in Delaware exposure test. Yellow pine panels faced South at a 45° angle for four years.

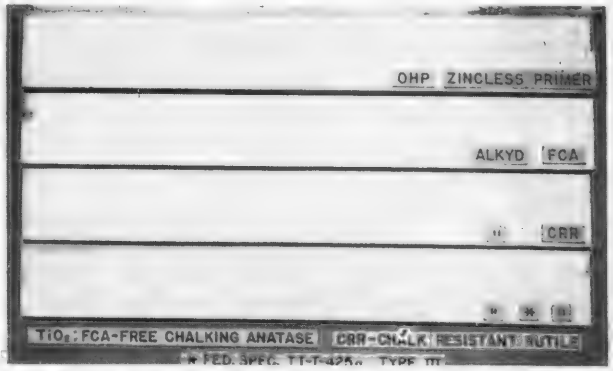


Fig. 7.—Comparison of type of TiO_2 pigment in Delaware exposure test. Cedar panels faced South in vertical position for four years.

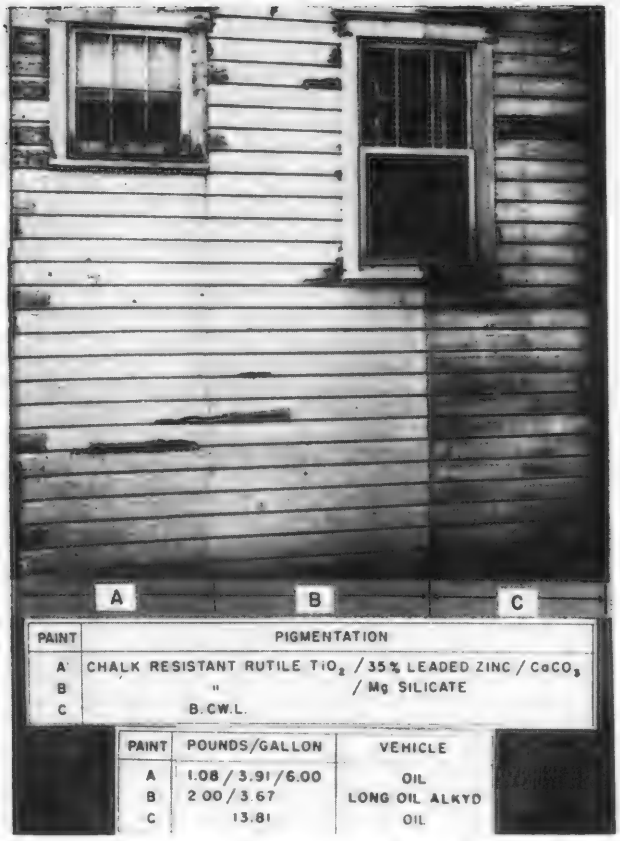


Fig. 9.—Durability characteristics for buff tints of the alkyd blister- and stain-resistant paint, as compared with conventional oil-type house paint and lead in oil. Southeast exposure for four years, repaints over yellow pine.

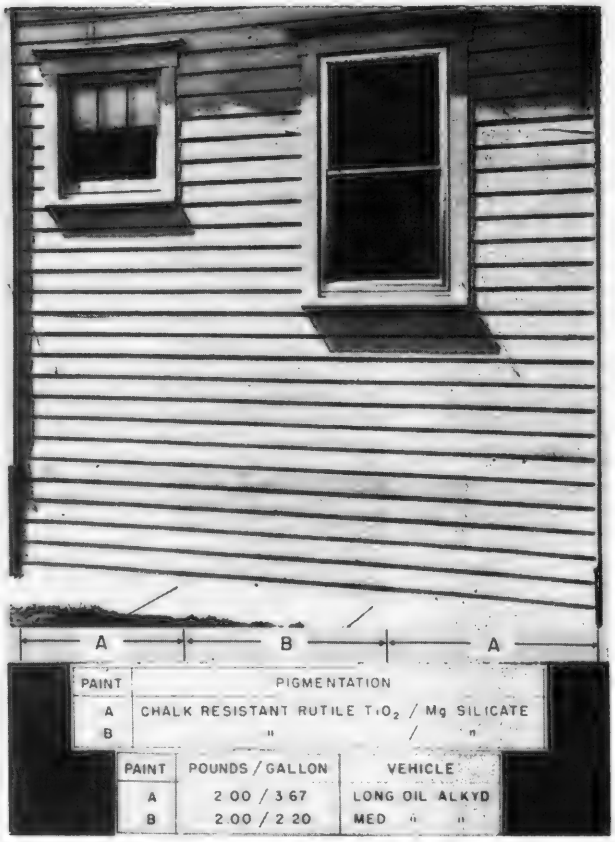


Fig. 10—General appearance after surfaces in Fig. 9 were repainted. Southeast exposure for 1.5 years.

the alkyd paint. Further, at the time this surface was prepared for repainting, the alkyd paint was outstanding in freedom from dirt and mold, and presented the best repaint surface of the three coatings used in this test.

The surface presented in Fig. 9 was repainted with long- and medium-oil alkyd blister- and stain-resistant paints tinted buff as shown in Fig. 10. The medium-oil alkyd paint, although more difficult to apply, gave better initial gloss and showed better gloss retention than the long-oil alkyd paint. As shown by the illustration, these alkyd blister- and stain-resistant paints are clean, with no staining evident from the copper gutter. To date, that is, in a period of one and a half years, these alkyd paints show very good performance characteristics.

Summary

1. None of the paint systems tested is satisfactory in performance regardless of substrate and moisture variations.

2. Under adverse moisture conditions, the alkyd blister- and stain-resistant paint used as the original coating on new wood is outstanding in performance when repainted with acrylic, polyvinyl acetate, oil, or alkyd type coatings.

3. Polyvinyl acetate and acrylic emulsion paints give better performance than do oil or alkyd type coatings on burned-off wood where moisture conditions are severe.

4. Chalk-resistant rutile titanium dioxide, used as the prime pigment, imparts exceptionally good durability characteristics to the alkyd blister- and stain-resistant paints.

5. The alkyd blister- and stain-resistant paints give good appearance and durability characteristics when used as repaint coatings on houses where no particular moisture problem is involved.

Discussion

R. S. Taub (Sherwin Williams Co.): Do you think the general public will find substantial benefit from this type of blister-resistant paint in view of: 1) its limited use? It cannot be effectively used over a previously painted surface containing a zinc paint. 2) Its use as a means of preventing blisters may actually hide a bad moisture condition, causing a deterioration of the wood behind the paint. Its use could mislead the consumer into doing very little about correcting his moisture condition, which could cause him considerable harm. 3) Its admittedly poor resistance to mildew?

Mr. Vannoy: 1) Its use over zinc is only restricted when the moisture problem is severe. 2) If a moisture condition exists, the blister-resistant paint, when applied to previously unpainted wood, may adhere sufficiently well to allow dissipation of the moisture through the film or back into the house. 3) Although mold was present, it was not adverse in the illustrations used, which covered 1½- and 4-year house-test exposures at Wilmington, Delaware. Doubtless better preservatives would help.

J. M. Sayward (Vermont Bureau of Industrial Research): It was stated that alkyd was poorer than emulsion on "burned-off" old paint. What would be the case on scraped-off or sanded-off areas? Isn't it probable that the burning produces a resin or char at the surface, which is the cause of poor adhesion?

Mr. Vannoy: 1) It is believed that the emulsion paint, properly formulated, would out-perform the alkyd on scraped-off or sanded-off areas unless the old paint film was completely removed from the substrate. 2) Charred wood at the paint substrate interface can cause poor adhesion.

Factors That Affect the Cost of Hardwood Kiln Drying[1]

EDWARD M. CONWAY

Owner, Lumber Drying Specialty Company, Grand Rapids, Michigan

Hardwood kiln drying costs in conventional kilns are discussed, and the more important, sometimes overlooked, factors that influence these costs are identified. Because of interwoven costs, few manufacturing and processing plants isolate and establish their true drying costs. Rules of thumb are given for ascertaining approximate costs of custom drying operations.

IMPORTANT TO ANY CONSIDERATION of the various aspects of wood drying is the answer to the natural question: "What does it cost?"

Very little factual data is available to the researcher on the cost of drying hardwoods. Most hardwood users and producers who operate kilns readily admit that they have only a shaky idea of their drying cost, even on the kind and thickness they sell or use most. The reason is that drying costs are usually thickly entwined with other manufacturing and processing costs.

Even most custom kiln drying is done on a guess-at-the-cost basis, mainly because 85 per cent of custom drying is done as a sideline. Less than twenty firms in the United States and Canada are known to be currently engaged in this endeavor as a primary business. While these "professional" kiln dryers know their costs, their prices are necessarily based on competition and averages, and do not fully reflect proportionate costs, specie by specie, thickness by thickness. Charges for kiln drying 4/4 inch air dried beech in 1956 ran the escalator of $12.00 per M' (thousand board feet) in Texas, to $14.50 in Memphis, $16.00 in Chicago, $18.00 in Grand Rapids, $20.00 in Ohio, $22.00 in Ontario, through $28.00 in the New York City area.

The actual cost of kiln drying 4/4 beech can be from $10.00 to $40.00 per M' or more, depending upon its beginning and final moisture content, the uniformity of m. c. required, the quality of the stock, the quality of the drying, the efficiency of the kiln plant, the know-how of the operator, the local labor costs, the proper quantity for the charge, the mechanization of handling, the assigned proportion of company burden, and many other factors. These considerations are in addition to the obvious variables of power rates, fuel costs and heat transfer efficiency, maintenance, fire insurance, sticker breakage, and depreciation on kilns and equipment.

In America today, few industrial processes in any field have as widely varied costs as the kiln drying of a unit of hardwood lumber.

The purpose of this paper is to itemize the more important factors that influence kiln drying expense, and to provide rules-of-thumb for ascertaining, approximate cost information. Also, figures are provided from a representative, commercial kiln drying operation in the North, which dries a fairly large volume. The figures and comments in this paper pertaining to kiln operation costs are for conventional cross-circulation kilns. The data presented is in part a composite of information obtained from furniture plants and custom drying firms, but mainly the material for this paper comes from the cost records of the Lumber Drying Specialty Co., writer's own kiln drying operation.

Basis For Figures

The Lumber Drying Specialty Co. is engaged only in kiln drying. There is no problem of separation of interwoven expenses on other manufacturing or processing, wholesaling or retailing. Consequently, the cost data is comparatively clear-cut. The cost system can be relied upon to foretell with reasonable accuracy what the expenses are to be on any inbound shipment of hardwood. A full description of the stock is necessary for this determination, however, even to its widths and lengths, and most important, its full range of moisture content.

A kiln drying cost system demands at least three expense separations: 1) kiln operation, 2) handling (stacking, yard and storage handling, and unstacking), and 3) assignable burden or company overhead. Each of these expense groups is divided by the board feet being processed to establish a cost per M' basis. The kiln operation total must be divided by the total kiln capacity used and by the number of kiln days to establish an average cost per M' per day in a kiln. This latter figure is further refined for varying drying time by ascertaining the variables and constants in the kiln operation expense group, and computing these according to the period of operating time desired (see Table 3). When figures from a previous period are being used for predicting current or near future costs, corrections are employed for any changes in expenses or footage.

Table 1 gives the expense items included in computing the cost of operating kilns, with the M. b. m. cost of each. Handling cost is broken down in Table 2. The third general cost classification, overhead, obviously cannot be detailed, lest aid or comfort be given competitors.

The expense of kiln operation, as itemized in Table 1, totals exactly $10.00 per M' dried. (This even figure is happenstance). Handling expense, as itemized in Table 2, totals $9.65 per M'. It can be seen, therefore, that the costs are $19.65 per thousand feet on the average of all species and thicknesses handled, plus overhead. Since Table 2 represents the average expense for the previous year, it differs slightly from the cost figure used in practice. A correction factor is applied for changes in certain expense items to bring the figure in line with current costs.

In evaluating the figures given in the tables, these things should be taken into consideration:

1. The figures shown are for a plant that processes a million feet per month, with down-time per kiln restricted to re-filling and maintenance. Where capacity and throughput is less, costs will

[1] Presented at Session IX, Wood Drying, of the 11th National Meeting of the FPRS, June 23–28, 1957, in Buffalo, N. Y.

The Author: Edward Conway has been engaged in custom kiln drying for many years. He began his present business in 1946, now kiln dries a million bd. ft. of hardwoods per month in fifteen kilns, with complete mechanization of stacking, handling, and unstacking. His college training was in business administration.

Table 1.—DIRECT EXPENSE OF OPERATION OF BATTERY OF FIFTEEN CONVENTIONAL INTERNAL-FAN KILNS AT GRAND RAPIDS, MICHIGAN, DRYING ALL SPECIES AND MOST THICKNESSES OF NORTHERN HARDWOODS (AS OF MARCH '57—BASED ON ANNUAL AVERAGE)

	Per cent of total cost*	Actual dollars per M.b.m.*
Labor, including supervision, fringe benefits and payroll taxes	29.0	$ 2.90
Steam cost	23.1	2.31
Electric power	16.2	1.62
Depreciation and amortization	10.2	1.02
Maintenance (equipment)	9.5	.95
Supplies	4.6	.46
Land and buildings expense	3.8	.38
Insurance	1.9	.19
Sticker breakage	1.7	.17
TOTALS	100 per cent	$10.00

*This table covers kiln operation only. It does not include cost of stacking, yard and storage handling and unstacking (see Table 2), company overhead, or profit mark-up.

Table 2.—EXPENSE OF LUMBER HANDLING AT LUMBER DRYING SPECIALTY COMPANY—COVERS STACKING, YARD AND STORAGE HANDLING, AND UNSTACKING OF ALL LUMBER PROCESSED 3–31–56 to 3–31–57

	Per cent of handling cost*	Dollars per M.b.m.*
Labor, including supervision, fringe benefits, and payroll taxes	64.3	$6.20
Depreciation and amortization on handling equipment	15.4	1.49
Maintenance of handling equipment	9.9	.95
Insurance	3.5	.34
Land and buildings expense	3.2	.31
Other (Gasoline for yard equipment, railroad demurrage, cleanup cartage, etc.)	3.7	.36
TOTALS	100 per cent	$9.65

*Does not include company overhead, nor any profit mark-up. The expense of kiln operation of course must also be added.

usually be greater, other factors being the same.

2. This firm processes mainly northern hardwoods, most of which is small mill stock. The proportion of short, narrow, and non-end trimmed lumber is higher than the national average for hardwoods.

3. About seventy per cent of the lumber processed is mechanically stacked and unstacked.

4. The company's wage scale is above national average because of location. Lumber handlers average $1.90 per hour, and machine operators more. An incentive system is used, however.

5. On the average, year around, only about one-third of the lumber kiln dried is previously air dried below 30 per cent m. c.

6. The figures are for custom drying, which reflects a slight additional expense for keeping lots separate and for some special handling as service to customers.

Guesses vs. Actual

Many lumbermen and woodworkers guess that the cost of properly stacking hardwoods for seasoning is in the $2.00 or $3.00 range. In the various articles written about mechanical stacking, there is usually an implication that the cost can be less than a dollar per M'. Such figures are low, because only the direct man-hour payments are considered. It is certainly inaccurate to claim a stacking cost of $2.00 per M' because two men, each paid $2.00, can handle 2,000 feet in an hour. The incentive rates at LDSCo range from $1.25 per M' on some kinds and thicknesses to above $3.00 on others, but the total expense of each handling is much greater because the pay of supervisors and fork-truck operators must be added, besides the payroll taxes, fringe benefits, overtime costs, and so forth. Direct and indirect labor is shown in Table 2 as amounting to $6.20 per M', but this is for handlings and includes package handling in yard and dry storage.

The average cost per M. b. m. per day in a kiln is usually guessed at $1.50 to $2.00. There is evidence that indicates that $2.00 per day per M' is not far off for the plant with very small kiln capacity, especially if it is located in a cold climate, has an unfavorable power rate, high labor costs, a high depreciation write-off, and poor lengths to process.

The average operating cost at LDSCo is closer to one dollar per day per M', however. The length of the kiln run makes a big difference, as can be seen from Table 3. The fewer the days in the kiln, the higher the cost per day. This is largely because the labor required to charge and discharge the drying chamber is the same, whether the kiln run is for two days or 60 days. Labor to control and test the drying is less per day on a long-term run. Steam and certain other costs vary somewhat, too, according to the length of the kiln run. Shorter runs require more steam per day because, no matter how long the time required for drying, the lumber and building is only heated up once and the stock is equalized and conditioned but once during the run.

Why Costs Vary Greatly

There are many substantial reasons why the expense of drying a thousand feet of hardwoods varies so greatly. Here are the more important factors that affect the drying cost:

Moisture Content, Beginning and Final: The beginning moisture content, particularly, has more influence over drying costs than anything else. Green hardwood requires, on the average, three times as long to kiln dry to six per cent as does the same stock thoroughly air dried first. Two-inch walnut or oak, if first air dried to fourteen per cent, can be kiln dried to six per cent by most operators in one-fifth or one-sixth the time required if it were green from the saw.

The cost of drying green versus well air dried beech, birch and hard maple, for example, can run from $8.00 to $12.00 more per M. b. m. on 4/4 inch thickness and $12.00 to $24.00 more on 8/4. The ratio of extra expense because of greenness is usually directly proportional to the thickness.

Partly seasoned hardwoods, say air dried to 35 or 40 per cent, require double the drying time, on the average, when compared to the same thickness and specie thoroughly air dried.

Kiln operation expense is obviously less when the final moisture content required is above the usual range. The uniformity of the moisture content of air dried or partially air dried lumber is important, too. Kiln operating expense per M. b. m. goes up when the charge varies in moisture content. Not only must the wetter boards be used for control samples, but extra time must be taken in the equalization treatment at the end of the run.

Species and Thickness: Needless to say, drying time and costs vary greatly according to the species and thickness being dried. But the number of different items to be processed has an effect on the costs, too.

A flooring plant, drying only one or two species, obviously has a lower drying cost than the furniture plant, dis-

Table 3.—APPROXIMATE AVERAGE COST OF KILN OPERATION AT LUMBER DRYING SPECIALTY COMPANY ON BASIS OF M.B.M. COST FOR EACH DAY OF DRYING TIME (AS OF MARCH '57 —BASED ON ANNUAL AVERAGE)

Days in Kiln	Cost per Day per M.b.m.*
2	$2.25
4	1.60
6	1.30
8	1.10
10	.98
14	.92
20	.85
25	.80
30	.76
40	.72
50	.70

*This table covers kiln operating costs only; the expense of handling, stacking, and unstacking is not included, nor is company overhead.

tribution yard, or custom kiln that handles 10 or 20 species, each in a half-dozen thicknesses. Inevitably, bad combinations are used from time to time in charging the kilns. This appreciably ups the cost on the easier-to-dry items, and affects the rest of the stock in the charge as well because of the m. c. equalization problem. Multiple species and thicknesses result in higher handling costs too because they must be kept separate. This results in the problem of part packages, part kiln truckloads, extra handling delays and interruptions in stacking and unstacking, and other drawbacks.

Quality of Kiln Drying: Poor kiln drying of hardwoods is nearly always unsatisfactory and wasteful of lumber, as well as much more expensive in the end. But, as for the drying costs only, hit-or-miss processing can be a great deal less expensive than careful, precision drying. When hardwoods are carefully boxpiled, including at least a partial sorting-for-length, with no unsupported stickers on the edge of the load, the labor cost can exceed by a 100 to 200 per cent the cost of stacking the same lumber "as it comes", any-which-way. Also, there are significant savings when no equalizing or conditioning is done. Proper sampling procedures take time; it is cheaper to guess at drying progress and final m. c. The same is true for other recommended operating procedures. If an operator is concerned only with driving out the moisture in the shortest possible time, without regard for a safety factor for degrade or damage, obviously he will have lower drying costs.

If drying quality doesn't matter, the kiln operator can dry lumber without certain supplies that help decrease degrade. Supplies can include endcoating for sample boards and for thick lumber, or yard pile covers, on down to moisture-meter needles and wet-bulb wicks. This comparatively minor account, "kiln supplies", exclusive of stacking sticks, last year totaled 46 cents per M. b. m. of lumber processed. One furniture plant reported an average cost for supplies of $13.00 per carload dried.

If quality is not a factor, and the kiln drying specifications allow a wide spread in final m. c., the drying cost will be very substantially less than for cautious, painstaking processing. From one extreme to the other, the expense can triple. Data from a box plant and from a high-grade furniture manufacturer, each drying the same species and thickness of lumber—though different grades, of course—indicate that insistence in minimum degrade, close m. c. tolerance, and flat, stress-free stock, raised drying costs almost 75 per cent.

Quality of the Lumber: Lumber of good widths and lengths is less expensive to kiln dry. Handling costs are appreciably higher on short, narrow stock. Kiln operating expense per thousand bd. ft. can be over 50 per cent greater on short lengths and narrow widths. When more or less lumber can be dried in the same kiln space, only the fuel and insurance expense is affected, besides handling, and this is insignificant except on green soft hardwoods.

One that has a normal capacity of 30,000 bd. ft. recently contained a charge of 36,427 bd. ft. The charge following, full to the brim with the same thickness of lumber, held only 23,610 bd. ft. Widths and lengths made the difference. The per day-per M' drying costs were 54 per cent more on the poor lumber.

Geographical Location of the Kiln Plant: Kilns in the South have a lower fuel cost, of course, but there are other climate advantages that result in lower drying costs. Most important is that the southern dry kiln operator has drier lumber to process because of more favorable air drying conditions. Also, he has no snow hinderance or removal expense, and has lower building expense and less maintenance.

Local Labor Costs: Naturally, the largest single expense in kiln drying is labor. Even with modern handling equipment such as mechanical stackers and unstackers, fork trucks, power transfers, and so forth, total labor costs are usually about half the total cost, exclusive of overhead, of drying a thousand feet of lumber. At LDSCo, it is 46 per cent of the total handling and operating costs together. Consider how this item will change from plant to plant, from village to city, from region to region. Lumber handlers and yard laborers are paid the $1.00 minimum in some areas and as high as $2.25 per hour in others; kiln operators rates seem to vary between $1.25 per hour to $8,000 per year.

Kiln Plant Efficiency: The dry kiln plant or department that has a high degree of mechanization for lumber handling will naturally have lower costs. Machines can stack lumber a great deal faster and surprisingly cheaper per hour, but the depreciation factor on such machinery is substantial indeed when translated into per M. b. m. handled. Also, the kiln plant layout—the physical relation of the kilns to the yard, to dry storage and to use or re-shipping point—is very consequential. The kind of kilns can affect the operating costs not only in drying time but in power consumption, maintenance expense, and handling costs. Some kilns require special piling.

Quantity: As with production-to cost ratios in almost any other field, a high volume of lumber being kiln dried in any single set of kilns usually results in lower costs in drying per M. b. m. The relation of the quantity to be processed, as well as the number of kinds and thicknesses, to the number of kilns can also be important costwise. The furniture plant or distribution yard that processes many kinds and thicknesses in only two or three kilns will have higher costs because of bad combinations. The least expensive operating cost per M. b. m. demands a full charge of like material—not more, not less, not mixed. Where a large number of species and thicknesses are to be dried, costs should be lower for the plant with more small kilns than for the one with half as many large-capacity kilns.

Know-How of the Operator: It has been said that the dry kiln operator in a plant with large kiln capacity can have as much control over the company's purse strings as the treasurer himself. This is a big exaggeration, of course, but the operator who knows his business can certainly effect a much lower per-thousand drying cost than a poor operator using the same facilities. The good operator can save drying time and improve quality. Even where drying time or quality can't be improved, the smart operator can bring through the kiln charge with two-thirds the steam as might the operator with less know-how.

Fuel Costs: While this is a substantial item, it is not as high proportionately as is commonly thought. The plant that buys oil or gas for its boilers probably only spends two or three dollars per M' to dry 4/4 green elm, for example. Assuming equalizing and conditioning at five per cent m. c., in our case this would be $2.31. Obviously, there is a widespread differential here, too, in cost from plant to plant.

Power: Most guesses on the power cost for the operation of a conventional dry kiln are lower than actual cost. The demand factor is not high, but kilns can and do run four times as long in the same week as most other electric-powered machinery in other departments. Many kilns run 168 hours a week, which results in high KWH. On a very favorable rate, the cost of electric power at LDSCo is $1.62 per M. b. m. of all lumber handled.

Depreciation on Equipment: A medium-small battery of kilns today costs more than $1,000 per thousand

feet of capacity, installed. Single kilns might be 50 per cent more. Depreciation on kilns alone, therefore, is substantial. Besides this, there is the depreciation on the handling equipment, which is even greater because of its comparatively short service life.

Equipment Maintenance: This item, including maintenance on both handling equipment and operating equipment such as steam plant and dry kilns, amounted to $1.90 for each thousand feet handled last year.

Real Estate Costs: This includes building repairs and maintenance, depreciation on buildings, property taxes, and so forth. These costs, too, are highly variable but it is a good guess that they will total 40 or 50 cents per M' on a nationwide average.

Insurance: In considering a cost basis for insurance, one should remember that fire risk, wind and flood damage, and so forth, are not the only dangers. Insurance to cover the kiln drying damage risk is not available, but if it were, its cost would probably average $8.00 a thousand, and much higher on certain thick, green, more refractory species. This cost, of course, is not included in the Tables.

Sticker Breakage: The mortality of stacking sticks is a greater factor for most kiln operations, it seems, than it is for us. Sticks are inventoried annually, and careful records are maintained on them. Last year, 4.3 stickers were broken per M' processed. The year before the figure was 4.6. Mechanized handling equipment cuts down on sticker breakage.

Assignable Overhead: The apportioned burden assigned to the dry kiln department in most plants varies according to the accounting system used. In some cases, it equals or exceeds the cost of operating and handling together. In this category are sales expenses, general office salaries and expense, taxes, some insurance, professional fees, and a good number of other expense items. These all add up to a sizable portion of any company's total expenditures. In custom kiln drying as a business, it can vary from an average of $1.50 to $8.00 a thousand.

Conclusions

The expense of kiln drying is indeed highly variable, for many reasons. On the same species and thickness it can fluctuate 400 per cent—from $10.00 to $40.00, on 4/4, and $20.00 to $80.00 on a thickness such as 10/4. Careful precision drying of green lumber costs more than is usually estimated.

A fair rule-of-thumb is that the overall average cost of most hardwood kiln drying in the midwest is $1.25 per M. b. m. per day in the kiln, plus handling and overhead. This decreases somewhat on long-term runs.

Green 4/4 cherry, for example, equalized at six per cent after 12 days of drying, costs the average furniture plant, distribution yard, or small mill about $15.00 per M' to kiln dry, besides handling expense and assignable overhead. It is a safe guess that the average cost for most firms of drying two-inch green walnut is over $50.00 per M' altogether. With an optimum drying time of 55 days, even at a low per day-per M' cost of 70 cents, plus handling and overhead, the total will be over $50.00.

Discussion

Rufus H. Page (Forest Utilization Service, U. S. F. S.): Do you have any data on air seasoning followed by kiln drying versus kiln drying from green?

Mr. Conway: The average cost for kiln drying green beech and birch is $8.00 to $12.00 per M bd. ft. more than for kiln drying air-dried stock of the same species. We have no cost figures on air seasoning.

Roy M. Carter (N. C. State College): Have you an indication of cost of equalization and conditioning?

Mr. Conway: We have no detailed cost figures on these operations. We equalize most 4/4 stock for 24 hours and this costs approximately $1.00 per M bd. ft. Conditioning costs on 4 and 5/4 probably run about 30 cents per M bd. ft.

R. C. Reitz (U. S. Forest Products Laboratory): What per cent of your lumber is equalized and conditioned?

Mr. Conway: About 2/3 receives this treatment. We do not do so for farm lumber, and so forth.

A Statistical Quality-Control Program[1]

VINCENT R. ROSS

Mill Manager, Draper Corp., Swannanoa, N. C.

This study was centered on the "unstable variation" that causes rejects in addition to the stable system of chance inherent in any process. The statistical quality-control program was successfully applied to the phases of specification, production, and inspection.

Introduction

SINCE THE BEGINNING YEARS of World War II, statistical quality control has maintained a vigorous if not phenomenal growth rate. In many industries it has become largely responsible for developing and directing a wide variety of production processes.

In actuality, what is statistical quality control? According to Grant:[2]

"Measured quality of a manufactured product is always subject to a certain amount of variation as a result of chance. Some stable system of chance causes is inherent in any particular scheme of production and inspection. Variation within this stable pattern is inevitable. The reasons for variations outside this stable pattern may be discovered and corrected."

It is the unstable variation upon which this paper is based.

An Experimental Program

In the Fall of 1955, the initial steps were taken at the old Biltmore plant toward embarking on a statistical quality control program. Approximately nine months' data have been accumulated on the techniques of specification, production, and inspection.

Specification: After a careful evaluation of the manufacturing process it became evident that the existing shuttle-block specifications were inadequate for use in a quality-control pro

[1] Presented at Session XII, Quality Control, of the Eleventh National Meeting of the FPRS, held June 23–28, 1957, in Buffalo, N. Y.

[2] Grant, E. L., Statistical quality control.

The Author: Vincent R. Ross received a B degree in forestry from North Carolina State College. He joined Draper Corp., in 1951 after working with the Forest Service. At Draper he is responsible for procurement and production of shuttle blocks.

gram. An attempt at revision was made to remove the ambiguity and spell out in more definite terms the exact requirements of the product being manufactured. With the advent of the Swannanoa plant, and the further revision of the specifications by Hopedale and Swannanoa management, a clear concise picture was made available. (Table 1.)

Table 1.—SHUTTLE-BLOCK SPECIFICATIONS

1. Blocks must be cut 1/16 inch full to green width and thickness and to exact length. blocks are to be cut square and not trimmed around edges.
2. Wane not exceeding ⅛ inch along edges of block is permissible. Width of wane may increase from ⅛ inch at 2½ inch distance to ¼ inch at block ends.
3. Blocks are to have straight grain, parallel to top and bottom of block. No curly grain is acceptable.
4. Pith, heart streaks, and worm-hole stains within 4 inches of ends on blocks under 18¼ inches in length and within 5 inches on blocks over 18¼ inches in length are not permitted.
5. All quarter and/or full bastard blocks will be rejected.
6. All blue-stained and mildewed blocks will be rejected.
7. Closed pin knots and other small defects are acceptable within ⅜ inch from ends of blocks, provided such defects run right angles to any block surface or will be removed by end trimming.
8. Side walls must be free of knots and defects the full length. Small knots running diagonally on the edges of the heart side of blocks are subject to the same specifications as wane.
9. Blocks 18¼ inches or less in length must have ends clear of knots for 4 inches on top and bottom of blocks. Blocks over 18¼ inches in length must have ends clear of knots for 5 inches on top and bottom of blocks. All knots on top and bottom of blocks must be ⅜ inch from side walls.
10. All blocks must be dipped to ½ inch in paraffin. All limb knots over ¼ inch diameter should be lightly paraffined.

Production: With the specifications clarified, the next step was in the direction of the production process itself, which in this instance was the sawmill. The problem, reduced to its lowest common denominator, was simply one of reducing the number of rejected shuttle blocks per inspection period. The standard practice after 100 per cent green inspection in the warehouse was to return an invoice to the various production units with the number and per cent of rejects contained in the inspection lot. Unless the cause was glaringly evident, no attempt was made by the inspectors to evaluate the reasons for rejection.

The next step in the quality-control program then was to classify and categorize the rejects.

This was done for each sawyer in the sawmill. Each man marked the sizes on his shuttle blocks with a different colored crayon so that the rejects were easily separated. Fig. 1 is a replica of the method used for classifying the rejected pieces. The information obtained from this method was then presented to the individual sawyer with added emphasis placed on the category or categories that were most in need of correction. In the initial stages of the program, a histogram was also used to give added impact to the presentation in the form of visual representation. (Fig. 2)

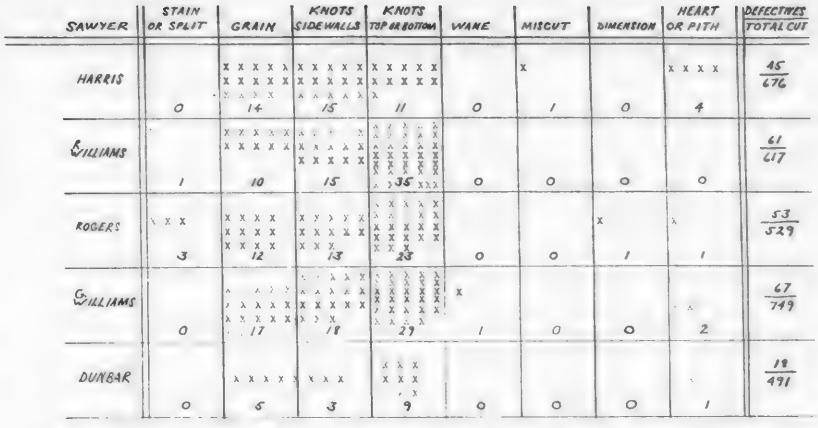


Fig. 1.—A weekly tally sheet for defectives for Draper Corp., Swannanoa plant.

The Control Chart

A tool was then needed to give information concerning the status of the production process. Three essential things had to be determined: 1) Was a change in percentage of rejects merely due to "the unstable system of chance causes."? 2) Was the process getting better? 3) Was the process getting worse?

The control chart would provide these answers and more. The chart deemed most effective for this purpose was the control chart for fraction defectives, more commonly known as the "P-Chart". (Fig. 3)

The problem was to interpret the control chart; in other words, where to place the control limits. To accomplish this end, an average of the results of all the 100 per cent inspections performed in 1954 was then taken as the average (p) for the control chart, and the upper and lower control limits (U.C.L. and L.C.L.) were calculated from this average. This set of limits now existing demanded no more of the production process than an equivalent of past performances. With a little study of Fig. 3, however, it was obvious that the process improved with such rapidity that, at the termination of the Biltmore operation, it was time for a new set of control limits. As before, these new limits denote the variability to be expected in the defective fraction when a state of statistical control exists. With the production process improving to the point where the average quality level (A.Q.L.) was consistently within the tolerance limits of 10 per cent or better, it was decided to supplement the 100 per cent inspection with a sampling plan.

Sampling Acceptance Inspection

The general procedure followed in the sampling acceptance inspection was

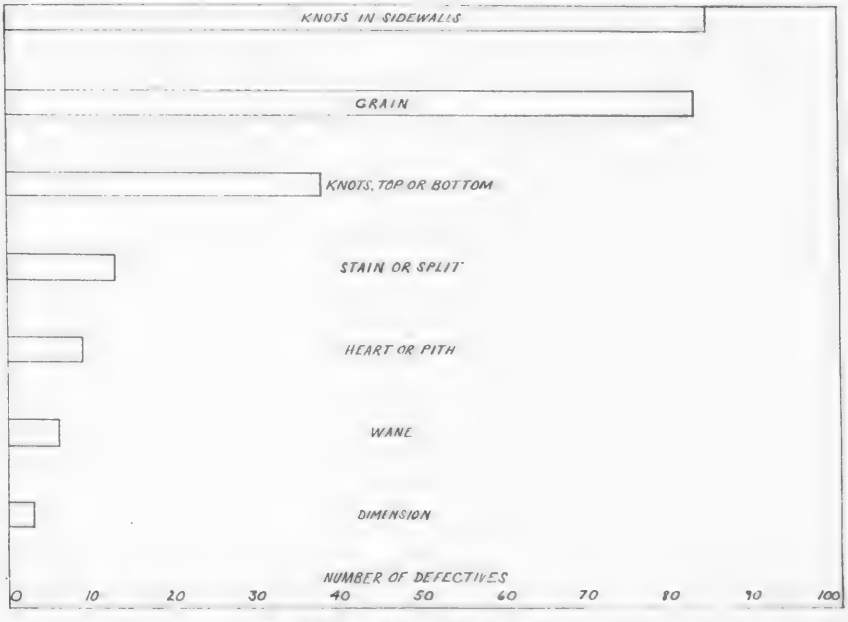


Fig. 2.—Histogram for defectives.

to submit a quantity of shuttle blocks for acceptance or rejection. A statistically calculated number were randomly withdrawn to represent the entire lot. On the basis of the results obtained from the sample shuttle blocks, a decision was made to accept or reject a lot. If the lot was accepted, it was funneled into the normal pipeline. If the lot was rejected, it was given a 100 per cent inspection with the defectives sorted out. Initially, the sample lots consisted of an individual sawyer's daily production (Fig. 4), but as the quality became more consistent, the inspection periods were extended to weekly production lots. As in 100 per cent inspection, the defectives were analyzed and the results reported to the sawyers (Fig. 4). The allowable per cent defective was still held at 10 per cent or less, regardless of lot sizes. Whenever feasible, the sampling plan was checked out with 100 per cent inspection, that is in rejected lots, and in only one instance did the sample reject a lot erroneously. The sample said the lot was 11 per cent defective, and 100 per cent inspection came up with 9.8 per cent.

Summary

Statistical quality control, since its inception a relatively few years ago, has been responsible for many improved production processes in a variety of industries. The manufacturing processes at Biltmore and Swannanoa have responded very favorably to these techniques. In order of their application, the processes are:

1. Specification—a revision that is clear, concise, and spelled out.
2. Production—a process that embodies the control-chart technique and its various ramifications.
3. Inspection—the elimination of unnecessary 100 per cent inspection and the substitution of statistical sampling, where practicable.

Recommendations

If the results obtained in the statistical quality-control program to date are accepted, it must be concluded that what has worked at Swannanoa also will work at other shuttle-block mills. From this hypothesis, then, the following recommendations may be made:

1. Initially select the shuttle-block mills with the best quality in the previous year and apply the technique of classifying rejects at 100 per cent inspection. The results could be sent to the various mills managers for presentation to their respective sawyers. An alternative method would be to return the rejects to the mills, and have the mill managers do the entire job.

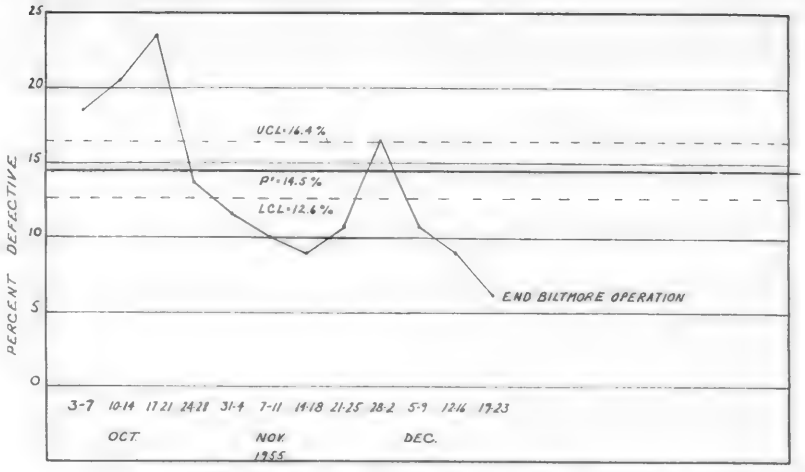


Fig. 3.—Control chart for defective fraction.

2. A P-Chart should be kept on each mill to check the results of recommendation No. 1 and to insure a state of statistical control. It would be well to point out here that the quality level that can be expected from the various mills probably will vary plus or minus several percentage points from the norm, depending on such things as sawyer skill, quality of timber, and management ability.

3. As the manufacturing process improves at the various mills and reaches an acceptable level, the 100 per cent green inspection can be eliminated and a statistical sampling plan substituted. Because this type of sampling is predicated upon the selection of a random sample, it would be more advantageous to take the sample as the shuttle blocks are loaded on the truck or railroad car. The mill manager or truck driver could be trained to perform this operation. When the shipment arrives, the sample could be examined and a decision made to accept or reject the lot. If the lot is rejected, a 100 per cent inspection will have to be performed.

4. These sampling techniques could also be applied to the purchase of hickory picker-stick blanks. If an agreement could be reached as to grade specification, and allowable number or percentage of defectives, a statistical sampling plan could easily be applied.

5. Potential areas where statistical quality control can be used are briefly listed as follows:

A. Dry Kilns—the use of an X and R control chart for moisture content.

B. Wood Machining—here again an X and R chart could be used effectively, especially on the molder for holding close tolerances. The control chart also serves as an excellent guide for checking different operators on any hand-fed machine.

Conclusions

Statistical quality control should be viewed as a tool that can influence decisions related to the functions of specifications, production, or inspection. Its most effective use generally requires co-operation among those responsible for three different functions or decisions at a higher level than any one of them. For this reason, the techniques should be understood at a management level that encompasses all three functions.

SAWYERS BLOCK MARK	DESCRIPTION OF DEFECTS AND AMOUNTS								RESULTS	
	KNOTS			GRAIN	HEART OR BARK	DIMEN.	MISC.	TOTAL REJECT	TOTAL CUT	% REJECT
	END	SIDE	EDGE							

Fig. 4.—Inspection report form.

How Can We Get More and Better Students to Study Forest Products Technology?

GROUP DISCUSSION

Industry—Education Division, Forest Products Research Society

The following is a transcript of the business meeting of the Industry—Education Division at the FPRS 11th National Meeting, June 23–28, Buffalo, New York. It was felt that the present serious problem of attracting students was of sufficient importance to all facets of the Society to warrant full publication of the minutes of the meeting in the *Forest Products Journal*.

A. J. Panshin (Michigan State U.): Well gentlemen, as you know we have a few questions that we would like to discuss, and perhaps the most important one has to do with some sort of a brochure designed to reach high school students. Bob Dosker tells me that only about 6 to 8 per cent of the student enrollment in general forestry is in utilization and technology areas, and I think possibly that it is even lower, unless we also count the lumber merchandising students. Now, what the reasons are, we have discussed many times, but I think the main reason is that we simply are not reaching the right students at the right time. As you know, Fred Wangaard and Herb McKean worked for about a year or so on a draft of a brochure that might be used to reach high school students. They came out with such a draft, which certainly they don't consider as a last version. In fact, it needs something done to it to make it sufficiently attractive for the students. The latest development was some time in May. There was a meeting of the NLMA in Boston at which time Fred Wangaard represented us, and I am very interested in briefing you people on what actually happened there and what came out of it. So at this point, without wasting any time, may I ask you to say a few words, Mr. Prange?

NMLA Action

G. Prange (National Lumber Manufacturers Assoc.): I have not very much progress to report. I believe that Mr. Wangaard went on record as saying that, if our sub-committee on Education so wished, they would be authorized to use the draft that he and Herb McKean prepared to consider career opportunities in the forest industry. The committee thanked him for that, and said that they would have it submitted to the members of the Association. That has been done, and thus far we haven't received any comments from it. The whole matter will be considered at our November meeting this year.

Mr. Panshin: I wonder if there are any comments or discussion? It seems to me that we have to find some way of moving this thing. What can this committee or this group do from now on, to see that somehow another year does not pass without any action being taken? Should we have a group selected from this group to meet with yours? In other words, should we have some standing joint committee? Bob, would you care to comment just where NLMA stands on this matter now?

A. J. PANSHIN

C. D. DOSKER

C. D. Dosker (Gamble Bros., Inc.): I wish I knew. The last two years we had a committee on education, and this is its second effort. We are trying to get money appropriated, and I think the recommendation of the committee was that a full-time man be employed by National to go around to the various schools to handle this whole problem of education. In every association you've got the problem of funds, just like we have in FPRS and the rest. This thing has become very critical, and I don't know whether you have seen this report of Chester. The figures are right there on the total forestry degrees conferred in 1955. Nine per cent of the total were in wood technology, 63 per cent were in general forestry, 9 per cent in wildlife management, and I am wondering where industry comes in this kind of picture. The day has passed when just anyone can sell our product. The time has come when I think this industry had better get smart and recognize what kind of sales competition we are up against.

Mr. Panshin: Well Bob, I think you will find that the schools are aware of the problem, and certainly they are willing to do more than they are doing now. Enrollments in wood technology curricula are always very low, and it seems to me the problem is how to attract the students from the high school. I think the selling job should be done by industry, because the students are very smart now. The first thing they ask you is "what is in it for me." In other words, "what kind of a future would I expect if I take this wood technology curriculum?" And frankly, what we tell them doesn't impress them; they want to hear something from you people.

Competitive Interests

Mr. Dosker: That is just exactly our thinking, but the trouble of it is that, when you've got such intriguing things as atomic power, light metals, and chemical industries, they drain off from your high school graduates the upper 6 or 7 per cent. The first thing that concerns me is the quality of the students we get. We are not getting enough boys that are high enough up the ladder to fill the top jobs that have got to be filled. With the progress this industry has made, there is a technological lag that I don't know how we are going to overcome. How are we going to get these youngsters in this field?

Mr. Panshin: Some of you probably are not aware of the existence of the publications put out by the combined aeronautical interests. These industries, the schools, and the commercial air lines, everybody, is in it. They put out several attractive brochures that obvi-

ously are aimed at the different levels, but mostly at the high school student. There is a compilation of the kind of positions available, what is expected from men in terms of experience, and what kind of beginners salaries and top salaries that can be expected in each rank. And there is also a listing of schools that offer such curricula, in some detail. It is industry that is doing all that, not the schools. But what impressed me was that the salaries they offer do not exceed by much those offered our own boys.

Mr. Dosker: Remember this about our industry: out of 17 million people gainfully employed in industry, three million are engaged in the forest products industries. And how are we going to get along with 60 or 70 wood technologists a year?

Mr. Panshin: Well, you people never even presented your story to the young people. They don't know that, they don't know that you are a big industry.

J. S. Bethel (N. C. State College): I think that the problem is even more basic than that. Somebody said that you've got to get these kids out of high school, and you do. But one thing we have got to do somehow or other is to have wood technology included among the possible careers that a boy considers in high school. Look at the percentage of the fellows employed in industry out of the general forestry curricula. A few of them switch over to wood technology in school, but many who don't take the jobs in industry just the same. Those kids when they were in high school were thinking about a career in the woods, and they find out later about careers in plants.

I've got one other point I would like to make, too: we worry a lot about the disadvantages that the wood industry has in competition with industries like aviation, chemicals, and so on, and they are real because of the nature of the industry. We've got a real advantage too, we haven't taken any advantage of, and that is that there are a heck of a lot more wood industries spread over the United States than there are competing industries. If we could marshall anything like a reasonable percentage of the individual plants for our program, we wouldn't have to have the fancy brochures. We would have the men in the Kiwanis Club, the Rotary Club, and the Lions Club seeing to it that one or two fellows from each major wood producing community went someplace and studied wood technology.

Mr. Dosker: This is one of the basic troubles in the wood industry. One of the very large companies in the wood industry called me on the phone in regard to a particular problem. It was costing him a lot of money, and they were losing a lot of stuff due to the development of stain. I said "I will send you some brochures" and I grabbed a handful and sent them down to him. He called me on the phone a couple of days later and said, "I got the information you sent down here, but I haven't got anybody in the organization that understands it." Now I said, "For heaven's sake I have been telling you for years that you can buy a wood technologist" (he said that this was costing him 90 thousand dollars a year) "you can buy somebody and put him on your payroll for seven thousand dollars a year and be at least 83 thousand dollars ahead." And that kind of a talk a man will understand. But the trouble with these people is that they don't want anybody in their organization that they feel knows more than they do. I mean, you take the small outfit and they have a sort of a pride of knowledge. They just don't want them. They are afraid of them. They are afraid to have anybody work for them that knows more than they do. The trouble of it is that they know darn little about a lot of things. Now I don't know how we are going to overcome this situation.

H. C. Moser (Gamble Bros., Inc.): Maybe we ought to forget the brochure for students and get a brochure for industry.

Wood May Be Losing Out

Mr. Dosker: Well I will tell you, this will right itself. I think we have got a transition going on now, and the velocity is increasing. We are getting more and more consolidations in industry. It is a hard row, and wood is losing out to many products that are inferior. What I am wondering about is this talk about tree farms and better utilization. Where in the world are we going to utilize this stuff if we don't get some uses for it, because we are losing out very rapidly. Just a little bit here a little bit there, and it's because we don't use the knowledge that is currently available. I don't know how we are going to get these youngsters enthused about wood.

Mr. Panshin: Bob, I would like to ask you a question. Why is it that AFPI, which is, after all, a part of your organization, spends so much money and effort in doing just what you said, tree farms, 4-H programs, growing trees, and so on, and there isn't a word about what your organization stands for, namely wood utilization. How come you have money for that kind of work, and you don't have two thousand for something that you say is so essential?

Mr. Dosker: Alex, you have posed a very very interesting question. I have also wondered about that, because in Kentucky we distribute to the school systems and everywhere around seven thousand copies per year of a publication for the AFPI on trees and on their protection. It is wonderful and very necessary, but we are not, by the same token, telling the children the opportunities that lie in wood industry. We are not telling the story of over 5000 items that we use every day that come out of wood. We are not getting that across to them. I don't know how we are going to do it, gentlemen, I really don't. I have been flabbergasted on this thing. I, myself, am on the first committee on education we have in the NLMA. They appointed the committee, and then sent us off with a great hoopla and didn't appropriate any funds for us to operate with. Because, frankly, they just can't see the necessity of this, they just don't understand. They think that you have got to take a boy out and start him in all operations, and the time doesn't permit that kind of thing anymore. You have to have a good education to be trained.

Anon.: There is another phase to this problem, too, not only getting back to the students in high school that are coming out, but what about all the men that teach it who don't know anything about it either. If they don't, how are they going to tell the students?

Mr. Dosker: Well, we had a great big storm session on that in the trade promotion committee on the fact that wood, as a structural material, is no longer taught in our engineering schools. They don't know anything about wood. They don't know what has happened to wood in the last two years. Now the Aluminum Company of America and Reynolds are all right there telling students about their material. You know, they don't even know wood is available anymore. They think the wood is all gone. You fellows in here have a job to do, also. I don't know how you can do it, but you have got a job to do in advising your boys in civil engineering and mechanical engineering as to just what can be done. And a lot can be done that way. Now that is a two-way sword. I think industry has got its job to do, but I think you fellows can do a lot of good in that direction also.

Demand for Technologists Exceeds Supply

R. M. Carter (N. C. State College): Doc Norton, who is chairman of the employment service committee, had a meeting yesterday, and this whole topic was discussed as the employment service committee interrelated activities. It

J. S. BETHEL

R. M. CARTER

has been obvious for the past two or three years that the industry wants more men than we have been able to bring out of the colleges. So as long as this demand for technically trained personnel, wood technologists, forest products technologists, whatever you want to call them, exists, it seemed to that group that we should have been pointing out this opportunity. It is a positive approach. Here are a great number of industries looking for high-caliber young men to go into supervisory capacity, and these young men in high school don't know about it. To get this fact across, we should have somebody in industry prepare news articles that would go to the Journal of Commerce and some other business publications of that type, then be picked up from the news service by newspapers throughout the area to acquaint the high school students and their parents and the advisors of the real potentials of the industry. That was one suggestion that was offered, that it go back to this industry-education meeting as their function rather than the employment service function.

Mr. Dosker: What we want in National is to get somebody who is thoroughly competent to go out and lecture to the various engineering schools throughout the country. Also, the same type of thing should be done at the high school level by selected people in the industry in their own areas. To get this story across takes somebody who can stimulate imagination and thinking. You just can't have somebody come up and tell the dry facts about growing trees, bugs, and all that kind of thing. That isn't going to get them anyplace. You have got to have somebody with enthusiasm, who can panit a picture and stimulate thinking. You've got to have the advertising literature that goes along after the guy makes his speech; he's got to have some brochures that he can pass out that list the opportunities that exist in the industry. We have had a lot of uncoordinated effort, the Timber Engineering Company has done a good job with their brochures and literature. A terrific job, but it has got to be coordinated. There is a lack of coordination somewhere, and if we could get this thing centralized so it can be coordinated instead of just spasmodic efforts, I think we would get somewhere. You are not going to get this thing started overnight. We are talking to boys that are eight years away from jobs.

Mr. Carter: What are the obstacles that your committee has run into in getting this program set?

Mr. Dosker: What do you think Jerry? I would rather have Jerry answer that.

Mr. Prange: The subcommittee has had only one rather comprehensive meeting, and all of our members have to study these things and discuss what we are going to do. As I mentioned before, this is only a subcommittee.

Mr. Panshin: Well, maybe with you coordinating it something will happen. I must say that it is rather discouraging from our side. I knew that you had this subcommittee. I knew that Mr. Carr was appointed chairman and, I have written a number of letters to him and never got a reply.

Mr. Panshin: Now so we don't disband without anything definite, I wonder if we couldn't have some proposals made from this group as to what our next action should be. I am going to pass this job on to Jim Bethel next year, but I would like to say that personally I would like to see some kind of a joint committee of the FPRS and your committee that will meet to explore these problems and maybe lead up to some decisions.

Highlights of Boston NMLA Meeting

Mr. Dosker: Well now, before you talk on that, Alex, may I read to you the minutes of that meeting in Boston. It explains that the outline prepared for the subcommittee was rather comprehensive. With other lesser emergencies deferred for further consideration, discussion centered around the practical methods of implementing the educational program, career opportunities, and a practice of using freshman classes in general forestry as a reservoir from which majors in wood utilization, wood chemistry, wood technology could be obtained. The general agreement was that a career brochure will be an important initial step towards stimulating interest in technically minded students in engineering and wood technology curricula. Dr. Wangaard distributed a draft of the publication "Career Opportunities in the Forest Products Industries", which was prepared by the committee of the FPRS Industry-Education Division Committee. It mentioned that the draft was in file form, and all the people and high school students could see it in an abbreviated form. The subcommittee received permission to use this draft for the development of career opportunity brochures, and our recommendation to the trade organization was that we make use of it. This will be given attention at the November meeting. I plan to submit a recommendation that the services of a full-time member for this purpose is warranted. The activities to be pursued should be: 1. Interest students at the high school level in preparing for the work in lumber and wood products industries; 2. Cooperate with forestry schools to acquaint the educators with the job we are trying to do through the industry; 3. Contact the architectural and engineering schools to focus greater attention on wood as a basic engineering material; and 4. Cooperate with the FPRS and other organizations in the coordination of the educational activities.

H. N. Stephenson (Sacramento Box & Lumber Co.): I would like to go back to this statement the gentlemen from North Carolina made in regard to counselors in the high school, because it ties in very directly with what we have found out in Northern California with the work we have been doing the past few years in high schools. In every California high school, there is some person designated as counselor both for the boys and for the girls. The counselors are only there to direct the efforts of the students, are not too well qualified, and they depend almost entirely upon information from industry to pass on to these students to tell them what fields possibly lie before them. Well, we found that they didn't have anything related to wood technology, and in too many instances the students that were being referred to Forestry were pretty short in brains. We have been concerned about it, so we finally decided that the most important thing we could do, to accomplish the most in the shortest time, was to work with these high school counselors rather than directly with the students. For the last six months that is what we have been doing. There is a committee of the dedicated members of the society who have chosen to go and meet with these counselors and tell them the story of the possibilities they may have.

Curricula Could be More Flexible

D. B. Richards (Alabama Polytechnic Institute): I would like to add a little comment here. We have been talking a lot about inertia. I wonder how much of this inertia business doesn't touch us, too. This whole discussion has been aimed at the high school students. We are assuming that

we have lost everything because we haven't gotten to the high schools. Maybe some of our curricula are so designed that if a student makes a decision after he enters his freshman year or sophomore year, or certainly no later than this junior year, we are not very cooperative with him. I think the real opportunity for us educators is to remake our curriculum to keep certain courses open that we like to offer. How many of them are aimed at suiting the students? I think we could set up a curriculum at a certain level of science, a certain level of chemistry, a certain level of mathematics, a certain level of engineering, and a certain level of biological subjects. Then give a boy an opportunity to express himself in some of these fields; allow a minor, but don't write it down in the catalog that he has to take it. One thing about an intelligent student is that he likes to think for himself. Don't call the courses for him, say that he has to take so many hours of chemistry and call it a minor, and you will be surprised how the intelligent student will rise. We have been rethinking this whole thing in our curriculum, and we are going to give it a try except that we are going to put a floor under all technical fields that can't go lower than so. Then you can often catch a boy at the end of a freshman or sophomore year who is majoring in something else by proper adjustment of his credits. Incidentally, it gives more freedom in electives. I think that you are going to be able to attract transfer liberal arts college students who have gone there and taken liberal subjects while they are feeling their ways around and then try to transfer into a technical school. I think this is entirely in opposition to everything we have said so far, but perhaps it's something we ought to think about.

Mr. Dosker: Richards, I think you are right.

Mr. Panshin: I feel that we are not as far apart as Boyd thinks; we are actually doing what he proposed in many places. I know that this is working out at Michigan State, and I see no reason why it shouldn't work out in other places, too. We have a group of students on our campus, on any campus. who are not too sure just where they want to go. And there are some good and bad students in this group. The problem is, how are you going to attract them. One simple thing that worked out in our packaging technology program was for some company to sponsor an ad in the college newspaper that said something about the opportunities in that particular industry, plus a reference to a particular curriculum on campus that fits the requirements of this industry. It doesn't cost industry too much, $15 to $25 maybe, but we were able to attract students from other areas, engineering for instance, and those that were not committed, simply because they didn't know we existed.

Mr. Carter: Would it help, Bob, to have someone from this education committee meet with your group?

FPRS-NLMA Cooperation

Mr. Dosker: I am very hopeful that we may be able to do this. I hope to do just that, because I think it is important that a group of this committee of FPRS meet with our group in Washington, and I think such a meeting could contribute a great deal toward this project.

Mr. Panshin: I think certainly it will be a move in the right direction. We hate to invite ourselves to your meeting, but if you people ask us to join you, maybe we could really come to something definite.

Mr. Dosker: I think it would be a very stimulating thing. The problem, I don't know whether to call it inertia or what, but I've served on a good many committees with National Lumber, and sometimes we come to a road block and just stay put, and we only have two meetings a year.

Mr. Panshin: Frank Kaufert, you just came in and didn't hear the discussion but we have spent all of our time discussing the possibility of this cooperation with the NLMA. Do you as, president of FPRS, have anything to say?

D. B. RICHARDS

F. H. KAUFERT

F. H. Kaufert (U. of Minnesota): Well, Alex, I just came in as you said, and I don't know exactly.

Mr. Panshin: But you have been thinking about this whole problem as long as I have, anyway.

Mr. Kaufert: Well, I think that everything that can be done in connection with the brochure is fine. To make the young men interested in the various fields, we should have something continuous, and I think that is where the AFPI and the National groups are going to be very helpful, because they have that kind of program too. For example, the AFPI is contacting schools on their fire prevention. I think they ought to put out a lot more literature on the opportunities in the forest products industry, and continually bombard the group so that we get some attention. So I would say certainly that the executive board and officers are very interested in this proposition, but don't just stop with the publication of a brochure. I think that is fine, but we need a lot more, something that is continuous. How much financing there is going to be I don't know, but maybe we won't need so much if we can get the proper backing. That is about all I have to say at this time, Alex. As I said, I don't know what is going on of importance, and you probably covered this same ground.

Mr. Panshin: Well, financing is important. There will have to be money to publish it initially, but we have at Michigan State, for instance, a list of brochures that describe our curricula and we don't charge anything for them. But there are cases where a company, say somewhere in Kansas, will ask "Will you please send us as many as a hundred copies, we have a mailing list and we will be very glad to put this literature with ours". In other words, there are many different ways this could be done. In this case, maybe some charge could be made to cover that cost. We still have a couple of items to cover, but could we leave it this way, that your committee would take steps to invite our group to a joint meeting to be held next November 18?

Mr. Panshin: There are two other items, one is more or less related to what we were talking about. Mr. Ellis, a couple of years ago at the suggestion of this committee, made a survey of the so called "working" wood technologists. I asked him to present to us the main findings of his survey.

E. Ellis (U. of Michigan): Essentially this was an attempt to find what recent graduates were doing, and to clarify the picture a little bit in this area of employment. I sent out 300 questionnaires to 23 odd schools in the country, and from that I got 190 replies, 168 of which are summarized in a reprint. The idea was to gather information from the recent graduates, that is, from those who have not been out of school more than 10 years. (At this point Mr. Ellis discussed results of his survey published in the February issue of the FOREST PRODUCTS JOURNAL as "Wood Technologists in the Forest Products Industry").

Industry-Education Technical Session

Mr. Panshin: Gentlemen, I still have another matter, and it has to do with the fact that probably next year

the Industry-Education Division will have a technical session, which we won't have this year. Some time ago, Nick Poletika came to me with ideas that he felt might be appropriate to build our session on, so I asked Nick to explain a little bit what he had in mind.

E. ELLIS

N. V. POLETIKA

N. V. Poletika (Timber Engineering Co., now with Union Lumber Co.): As Alex pointed out, about two or three months ago I wrote to him about the possibility of presenting a paper at this meeting, covering some of the things that industry is doing for education. He wrote back and said he thought that program was a little bit ambitious, and perhaps we ought to take a little time here to expand the program for next year. So I jotted down here on a piece of paper I handed out some ideas which perhaps might be worthwhile. I think it might be worthwhile to split this whole field of educations roughly into five categories: the first one would be education of producers, the second one would be education of designers and consumers, the third one would be student education, the fourth would be professional education, and the fifth would be industry and association educational methods. Briefly, what I am trying to bring forth is that in addition to trying to get students there is plenty of work to be done on showing the producers why they need technical people, and also a little bit more about the products. The same thing applies to the designer and consumer. I think there is definitely work which is being done; our company does it, associations do it, your universities do it, which is education of the professional people outside the lumber industry, in the forest products industry, the engineering industry, the architects, and so on. They are in some respect the users, and have done a tremendous work in that direction, and as a service to the industry I think something ought to be done about that. We ought to cover this whole field, and then assign speakers to each of these, or get speakers for each of these groups. It would be excellent if we could get somebody who is actually an architect or engineer to give us his slant on it. An educator to take care of the student force. A man from the producers to give his point, and of course somebody from the association or organization to give their viewpoint.

Mr. Panshin: Well, what is it, about 2 hours, 2½ hours, for technical sessions?

Anon.: Let's request a full day program, then.

Mr. Panshin: I don't know whether they would allow that, but we might certainly try.

Mr. Dosker: This number two here I think is really something. I think Nick has a wonderful idea, because this number two is tricky.

Mr. Poletika: I think it ought to be emphasized because it has an undertone to it.

C. DeZeeuw (N. Y. State College of Forestry): There was a paper on "Wood as an Engineering Material" for the ASTM several years ago. It was widely distributed, and is along these same lines. However there is new material. Many people have no idea in this industry of some of the facts that he has presented here.

Mr. Panshin: Well gentlemen, maybe this is the program, but of course it will be up to the executive committee to decide whether it is possible to put up the whole program or a part. Maybe as someone suggested, it may be possible to set up meetings on educational and lumber promotional techniques on the whole day basis and still retain continuity of ideas. The name of this group is the Industry-Education Division, and therefore I think it is very properly a subject for this group to handle. But the only difficulty might be that it may prove to be too long to cover adequately in one session. Jim, that probably will be your headache.

Mr. Bethel: This sort of thing is certainly of interest to all of us, and the promotion of wood, the use of wood, is life blood for us. However, I would like to point out the danger in mixing trade promotion. I am interested at this point to hear about the plans that were considered by the NMLA earlier where they wanted to assign a man to do several things, one of which was trade promotion with education promotion. Now I suspect that the man assigned will do about 90 per cent trade promotion and 10 per cent promotion of technical education.

Mr. Panshin: I hope it is the other way around.

Mr. Bethel: I hope so too.

Mr. Dosker: Let me ask you this. Why couldn't this thing be condensed into a panel discussion? Because I think if you could get a panel of five people and restrict each one to 20 minutes in the speech and 20 minutes in a discussion period after, that will take care of a 3-hour session. Now you could start this thing at the luncheon session in which you have the speaker kick the whole thing off. And then go right from there into your panel discussion and carry on until 5:30. I think you would have them all staying until the last drop.

C. DEZEEUW

E. A. ANDERSON

E. A. Anderson (N. Y. State College of Forestry): Alex, there is one other way to do it, and that is to have a subject-matter committee meeting in the morning and to continue with a technical session in the afternoon. That would give you about ¾ of a day right there.

Mr. Panshin: In other words, get all the business to a minimum and actually start the program in the morning.

Mr. Bethel: I think we have to indicate sometime today to the executive board if we want to put in a bid.

Mr. Panshin: Is there anyone who thinks we shouldn't have a technical session next year? Well, apparently no one disagrees. Jim, as I see it the consensus is that we will have a technical session and that it probably will be built around the program that Nick proposed, with such modifications as you see fit to make, as you develop it. Gentlemen, are there any other questions or suggestions? This meeting is adjourned.

Abstracts From Current World Literature

Wood Chemistry

Stewart, C. M. Status of cambial chemistry. Tappi 40, no. 4: 244-56 (April, 1957).

This review covers the somewhat limited information which is available on the chemistry of the cambium. The production, translocation, and composition of nutrients utilized by the lateral meristematic tissues are described briefly. The effects of ambient conditions on the activity of the cambium and their relation to the initiation of cambial activity are discussed. Ambient temperature appears to be the chief factor responsible for controlling the rate of enzymic reactions associated with secondary growth; it is suggested that the vernal increase in ambient temperature, rather than the physical transport of auxin from the developing buds, is responsible for the basipetal initiation of cambial activity. The rate of cell division in the cambium and its effect on the structure of the derivative cells is considered. The distribution of materials such as water, inorganic substances, sugars, tannins, and nitrogenous substances, which are "extraneous" to the cell wall, is discussed. The cell-wall components are considered in relation to their variation during the differentiation of cells produced by the cambium. Pectin appears to be present in comparatively small quantities, and there is no reliable evidence which suggests that pectin is transformed into other substances after it is laid down in the middle lamella and primary cell wall. The cells of the cambial zone appear to contain little if any lignin. about 20% of cellulose, and large amounts of noncellulosic polysaccharides. As differentiation proceeds, cellulose is laid down in the cell wall, followed by the deposition of most of the lignin. The chemical mechanism of lignin formation and of lignin deposition is discussed. A portion of the lignin appears to be linked by covalent bonds to the noncellulosic polysaccharides. [Bul. Pap. Chem. V. 27, No. 10]

Pearl, Irwin A., Beyer, Donald L., Johnson, Barbara, and Wilkinson, Sally. Alkaline hydrolysis of representative hardwoods. Tappi 40, no. 5: 374–8 (May, 1957.

Thirty-four representative hardwoods (including largely species of poplar, birch, oak, and maple) were extracted with boiling 1-*N* sodium hydroxide solution, and the alkaline extracts were analyzed qualitatively by paper chromatography and quantitatively by paper chromatography and spectrophotometry. The following compounds were determined quantitatively: vanillin, syringaldehyde, vanillic acid, syringic acid, *p*-hydroxybenzoic acid, ferulic acid, and *p*-coumaric acid. The presence or absence of one or more of these compounds in certain genera or in individual species within a genus should prove useful for taxonomic classification purposes. All species within the *Populus* genus and the closely related *Salix* genus contained *p*-hydroxybenzoic acid, but these were the only two genera in which it was found. All species tested yielded vanillin, syringaldehyde, vanillic acid, and syringic acid, but the other compounds were much more specific. Because the present report includes only preliminary data obtained on single samples of individual species, most conclusions must be considered qualitative in nature at this time. [Bul. Pap. Chem. V. 27, No. 11]

Pathology

How to recognize various stains in timber. *Furnishing World*, Vol. 41, No. 831, December 1956, p. 33.

Several types of stains exist in timber and these may be broadly classified as being caused by chemical reaction, surface moulds, sap stain, incipient decay or in specific varieties, by bacteria.

The best-known chemical stain is that found in oak and caused by iron fastenings. This discoloration will be found in any timber which contains large quantities of tannin and in time corrosion of the metal will occur.

Surface mould stains, which are caused by fungal growth on the outside of damp timber, are temporary in their effect and may range in colour from yellowish to pink or green. These surface moulds do not affect the physical or mechanical properties of the wood and when the moisture content is reduced to below 20%, will be permanently cured. Blue sap stain is caused by a fungus which, while harmless itself, may mask the attack of wood rotting varieties. No corrective measures are possible once the timber has been attacked but susceptible species should be dipped soon after felling.

Stains caused by the onset of decay are usually readily distinguishable, being in the form of reddish or brown streaks running parallel to the grain, or small patches of abnormally light coloured wood. A quick check of the true condition of the timber can be made by prising up a splinter of the discoloured wood with a penknife. If the splinter breaks off short as it is lifted it is certain evidence that the stain is caused by incipient decay. To avoid undue wastage of timber it is often possible to cut out the stained area although wood near the affected portion should be suspect. [F. D. C. Tech. Bul. V. 6, No. 34]

Waste Utilization

Guy, Clarence J. Wood waste shaving and sawdust baler. U. S. patent 2,780,989. Filed March 4, 1953. Issued Feb. 12, 1957. 4 claims. Assigned 50% to R. H. Guy. [Cl. 100–218] M. 556.

Wood waste (shavings, sawdust, etc.) is prepared for handling and use as poultry litter by drying for 3–9 min. at 350–450° F. to a moisture content of 5%, compressing to about one-third its normal volume, and baling with wire. [Bul. Pap. Chem. V. 27, No. 11]

Composition Board

Lampert, Helmut. Process for the manufacture of building boards from spruce tanbark. Zellstoff u. Papier 6, no. 3: 80–3 (March, 1957). [In German]

At the German leather factory, VEB Lederfabrik Hirschberg, spruce bark (outer bark or cork cambium and inner bark or bast) is extracted with hot (95–98° C.) water by the countercurrent process for the manufacture of tannins (11.5% of the bark substance). This process also removes about 7% soluble nontannins, 15% water, and other materials from the bark, leaving a tanbark residue of 70–75% moisture content. Previously, this material was dewatered mechanically with roller presses and then in drum driers and burned as fuel of low heating value. Recently, however, a process for its conversion to building board has been developed. The extracted tanbark is conveyed to a storage tank kept at 65°; from here it is fed continuously to a disk hollander which beats the pulp at 4% consistency to 18–20° S.-R. A pump transports the beaten pulp to mixing chests of 20 cu.m. maximum capacity, where 2% bitumen emulsion is added and precipitated on the fibers by addition of sulfuric acid to a pH of 4.5. The stock flows through a measuring tank into a molding chamber, where it is dewatered on both sides with simultaneous application of pressure and vacuum, leaving the chamber in 3–4.5 min. (for a board 11 mm. thick) with a dryness content of about 30%. This is increased to about 40% in a subsequent cold press under identical pressure and time conditions. The porous boards are then dried in a drying tunnel, equipped with upper and lower wires between pairs of rollers not more than 150 mm. apart and having tension-controlling devices, and subsequently heat annealed at 160° for 2 hr. After conditioning for 24 hr. in stacks, the boards are seamed (trimmed and bordered) as usual and made ready for shipment. The water absorption of the boards is 20–30% in 24 hr., as compared with 60–70% without addition of 2% bitumen. [Bul. Pap. Chem. V. 27, No. 11]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Around the World in Forest Products Research and Development

Timber Preservation in Great Britain

Condensation of an English translation of an article by H. A. Cox, which appeared in *Houtbereiding*, No. 4, 1957, Journal of the Netherland Foundation Institute for Wood Preservation.

Recent work with timber preservation in Great Britain can be considered in three categories: pure research, development of preservatives, and expansion of facilities for preservative treatments.

Pure research has been concerned with the study of deterioration of timbers in cooling towers, specifically the form of decomposition caused by ascomycete fungi of the *Chaetomiaceae*. One line of investigation has dealt with the biology of certain wood-destroying coleoptera, including the pin-hole or shot-hole borers. Two valuable papers describing recent investigations on pin-hole borers were presented at the 1956 Convention of the British Wood Preserving Association. Other papers presented dealt with timbers for coast defence work, the effect of wall linings on the growth of fire in buildings, termites destructive to timber, and the preservation and maintenance of transmission poles.

Several series of comparative tests of the efficacy of different preservatives in varying concentrations have been inaugurated. In progress are tests of the relative value of various preservatives and treatments against marine organisms, mainly teredo and gribble, the relative durability of treated and untreated timber in a mine, and field tests of fence posts and so forth in soils of different types. Various of the better known preservatives applied either under pressure or by surface applications, dipping or steeping, and including types with tar oils, water-soluble salts and oil-solvent types have been used in the tests.

Coal-tar creosote continues in favor for treating railway sleepers, transmission poles, timbers for coastal defence work, and for the protection of river banks. For the latter, water-soluble preservatives of the copper-chrome or copper-chrome-arsenic type have been used to some extent with success. Water-soluble preservatives are now being more widely used for the treatment of framing timbers and louvres in water-cooling towers, although creosote is still used for the treatment of the exteriors of some wooden towers.

Oil-solvent preservatives, including pentachlorophenol, metallic naphthenates, and chlorinated naphthalenes are being used more extensively for treating interior timbers in buildings where the strong odor of creosote or tar oils may be objectionable. For outdoor purpose, a heavy, less volatile oil is preferred, but for treating building timbers a lighter oil that will volatilize in the course of a few weeks or months and leave the timber in a condition for painting is usually preferred. For the treatment of interior woodwork and furniture in place against decay and insect damage, various proprietary liquids employ either pentachlorophenol, metallic naphthenates, pentachlorophenyl laurate, or the water-soluble sodium pentachlorophenate. It is claimed that the first three are effective over long periods and will not leach. Pentachlorophenyl laurate is said to be more readily soluble than is pentachlorophenol.

One of the newer preservatives has for its active ingredient one or more chlorinated naphthalenes, mainly mono- or dichlornaphthalenes. These are said to be more effective against fungi than against insects, and where necessary, the solution is fortified with an additional insecticide. It is claimed that this type of preservative has very good penetrating powers, so pressure treatment is less essential for certain purposes.

In recent years there has been a remarkable increase in the number of pressure plants. A few years ago, the greater number were employing creosote as the impregnant, while only odd ones injected water-soluble preservatives. Today there are many more plants using copper-chrome, fluor-chrome, or copper-chrome-arsenic solutions than creosote. Even so, the volume of timber pressure treated with creosote is almost certainly well in excess of that pressure treated with all other preservatives together. There are few districts so remote from sites of plants as to render pressure treatment difficult.

In recent years, the treatment of timber that is to be used for food containers has become more frequent, as, for example, refrigerators and refrigerator vans, boxes and crates, and in buildings where other foods are stored. Because creosote has a strong odor that may affect the flavor of edible goods, a tasteless, colorless and odorless preservative is more appropriate. Boracic salts in aqueous solutions have recently been employed both in buildings and for other work. These have been used for the treatment of building timbers and are said to be effective against furniture beetles and other insects as well as fungal decay. In the past, preservatives less corrosive and less subject to leaching have been preferred for outdoor work in Britain. It is claimed, however, that borax and boracic acid in mixture are much less apt to corrode metals than boracic acid alone. At the same time research has been promoted to discover some method of fixing the preservative in the wood and overcoming leaching. Further advantages of these preservatives are that they do not taint foodstuffs and impart no color to the wood, desirable qualities where food-containers are concerned.

Scanning World-Wide Forest Products Publications

Japan

Deformation of wood due to the change of humidity in atmosphere. Yoshio MINAMI & Yonosuke FUKUDA. Wood Industry, V. 12, no. 3. Published by Wood Technical Assoc. of Japan, Meguro, Tokyo, Japan.

(1) For a few species of wood, the extension or contraction of wood fibres was measured by the creep testing apparatus.

(2) Wood fibres extend or contract strictly following to the change of humidity. In atmospheric condition, the change of temperature is so small as compared with that of humidity that the effect of the change of temperature can scarcely be recognized.

(3) There may be a retardation of time between the change of humidity and that of strain, and this is noticed in the test results. But as the amount of retardation of time can not be estimated at several values of humidity, for the experimental data a straight line formula $d\epsilon/dt = \alpha\, dH/dt + \beta$ is given, where ϵ, the strain, H, the relative humidity, t, the time and α and β are constants. The rate of extension or contraction due to the change of humidity can be compared by the value

of α. The value of β will be zero if a large number of experimental data is obtained.

(4) Generally speaking, the value of α may be the same independent of species in each direction. If this conclusion may be allowed, the values of α in the A-, R- and T-directions are about 2×10^{-4}, 4×10^{-3} and 8×10^{-3} %/hr, %/hr respectively.

(5) The deformation due to the change of humidity will be influenced by the antecedants of moisture absorption. In the practical condition, the wood fibres near the surface extend or contract cyclically showing the complicated loops between $d\varepsilon/dt$ and dH/dt.

Studies on Chipboard Produced from Planer Shaving Particles (Preliminary Report). M. ōta and J. Tsutsumi. Journal of Japan Wood Research Society. V. 3, no. 3. [English Abstract]

In this study, the authors examined the properties of chipboard made by varying the particle size and the concentration of aqueous solution of urea resin, but fixing the other conditions (resin content 3.3 per cent, NH_4Cl 10 per cent, pressing time 40 min, temperature of hot plate 140° C, raw material 250 gr, thickness of chipboard 0.7 mm), and discussed the quality of planer-shaving particles of Shioji *(Fraxinus commemoralis* Koidzumi) as raw material for chipboard.

The following conclusions were obtained:

1. The larger the particle size, the higher the bending strength. 2. There are no significant effects of the concentration of aqueous solution of urea resin to the moisture content, specific gravity. Brinell hardness, and thickness expansion, but the higher the concentration of aqueous solution of urea resin, the higher the bending strength, and the lesser the hygroscopicity and the linear expansion. 3. The quality of chipboard produced in this experiment is somewhat inferior to that of Homogenholz (1st grade) in bending strength, hygroscopicity, and thickness expansion, but it can be presumed that the planer-shaving particles of Shioji are a possibility as chipboard raw material.

Studies on the Transmission of Gas through Wood. II. On the Relation between Gas Pressure and Transmission Velocity of Gas Parallel to the Grain through Sapwood and Heartwood of SUGI. H. Watanabe and K. Aso. Journal of Japan Wood Research Society. V. 3, no. 2. [English Abstract]

In this study, the authors experimented to ascertain the relation between gas pressure and transmission velocity of gas through sapwood and heartwood of Sugi into which nitrogen gas was transferred parallel to the grain by pressure. The transmission lengths were 1, 1.5, 2 and 2.4 cm. and the transmission area was 3.14 cm^2. The applied pressures were 10 15, 20, 25, 30, 35, 40 and 45 mm of Hg. The moisture contents of wood were 11 to 12 per cent, and the temperatures of wood were 27° to 30° C.

The results showed that the rate of transmission is inversely proportional to the gas pressure when the length is the same, and directly proportional in practical accuracy to the transmission length when the pressure is the same. On the average, the rate of transmission through heartwood is 1.76 times as large as that through sapwood in this experiment.

Review of Publications and FPRS Section Papers

The Use of Thin Kiln Stickers in the Drying of Lumber

P. F. Deverick, Kent Coffey Mfg. Co., Lenoir, N. C. Part of a panel discussion on "Stacking, Stickers, and Related Problems" at the FPRS 11th National Meeting, June 23–28, 1957, Buffalo, N. Y.

To many, kiln sticks seem relatively insignificant and unimportant. At Kent Coffey Mfg. Co., kiln stickers are evaluated for insurance purposes in excess of $50,000. Kiln stickers must constantly be replaced because of loss through breakage and wear. Poor durability may cause a needlessly-high cost of replacement. Experimentation and observation have shown that, from the standpoint of durability, freedom from twist and warp, and lightness, cypress is unsurpassed.

Kent Coffey advocates the use of thin stickers, the ½ inch, rather than the ¾ inch or even thicker stickers. Thin stickers were first used because stock of this sort was available when kiln stickers were needed.

By use of thin stickers, the total air space between layers is decreased, which increases the velocity of the air in lumber drying. Some years ago, O. W. Torgeson of the Forest Products Laboratory ran an experiment in which he found that sticker thickness affected velocity as follows: ½ inch, 454 ft. per min.; ¾ inch, 389 ft. per min.; 1 inch, 367 ft. per min.; and 1¼ inch, 330 ft. per min. The comparison shows that, as sticker thickness increases, velocity definitely decreases. This means that the drying rate also decreases.

An experiment was set up in which two test boards, cut from the same piece of lumber and with exactly the same moisture content, were inserted in the leaving-air side of two adjacent kiln trucks, one with ½ inch and the other with ¾ inch stickers. The fans were set to circulate the air through the load without reversing, with air always leaving on the side where the tests were located. These boards were periodically weighed as accurately as possible, and it was found that the board located in the truck with the thin stickers lost moisture at a slightly faster rate, staying about .1 to .3 of a per cent lower in moisture content. At the final weighing, the thin-sticker test board averaged .32 per cent lower in moisture content. These particular boards were from air-dried stock (18 per cent m.c.) and undoubtedly the effect would be more pronounced in stock of a high moisture content.

More important is the increase in kiln capacity gained by the use of thin stickers. The use of ½ inch stickers gave a 9.1 per cent increase in kiln capacity. The actual increase in kiln volumes was about 35 M board feet, or approximately 1 day's cutting for 3 cut-off saws. This increase in capacity also applies with regard to cooling shed or yard space.

There are some objections to the use of thin stickers. Greater entrance and frictional loss causes an additional back pressure, which results in a slight increase in power consumption. In most cases, however, this is almost negligible. There is undoubtedly a higher loss of stickers by breakage when southern pine is used. When a durable species such as cypress is used, this does not seem to be the case.

Cost is a highly variable factor. It was found that thin stickers from southern pine were costing 9.16¢ each, while the usual ¾ inch sticker could be obtained at approximately 11¢. It is doubtful that suppliers would furnish the thin sticker at less cost than the usual thickness, since 4/4 lumber would be used to produce either. If a wood-using industry is in the position to manufacture its own stickers, however, much of the thin lumber that has little or no inventory value could be utilized. Kent Coffey has manufactured a great many stickers from thin poplar rejects, with a yield of about 756 stickers per 1000 board feet, the waste be

ing utilized for small dimension stock such as draw guides.

Results favor the use of the ½ inch sticker mainly because of the increase in kiln capacity without any loss of drying efficiency. This increase in capacity, combined with the faster drying schedules now in use, may be the answer to the problem of meeting production requirements for dry lumber.

The Utilization of Some Little-Known Species for Plywood Inner Plys

J. R. Bolon, Production Manager, Roddis Plywood Corp., Marshfield, Wis. Upper Mississippi Valley Section Meeting, October 16, 1956, in Wausau, Wis.

Utilization of some low-grade species in the plywood industry is becoming an economic necessity. Availability and cost are making native woods such as cottonwood, aspen, and sycamore attractive to the manufacturer. Tropical woods are being tried, but as yet no one species is used extensively.

Cottonwood has certain limitations. In lumber-core form, it has poor machineability. When combined with woods such as soft maple or elm in veneer core construction, it is more acceptable. Cottonwood plywood requires a decrease in the feed speed for machining and an increase in the speed of the cutterheads. Customers who know how to handle cottonwood place repeat orders. The customer that has not been informed of the proper handling method complains. In the future, cottonwood will be the only wood available at an attractive price to the manufacturer, which makes it important to acquaint customers with its properties. Density variations inherent in cottonwood cause wavy doors when used for crossbanding. Experiments with decreased pressure, lower heat, and so forth, were unsuccessful.

Roddis has tried to get customer acceptance of sycamore, and it is believed there will be little question of acceptance by the trade. Sycamore drys and machines well, and glues easily. The problem is to get logs that do not have excessive ring shake. So far, Roddis has been able to get enough sound logs to make production runs. Sycamore has been combined with elm to make a veneer core panel that is very saleable. Special machinery is not needed for machining this combination.

Elm veneers have been used as core material for a long time. The stiffening of competition has upped the grade of core stock, however, and knots and voids are no longer acceptable. This means that plywood manufacturers must get better raw material or spend more money in processing. Elm veneers must be dried carefully to obtain flat material. It has a tendency to curl and become wavy if dried too quickly. It has been used for centers, panels, and crossbanding for doors. Unless it is very flat before it is glued in, it has a tendency to cause lapping in the hot press. To get a sound sheet of veneer, elm must generally be plugged; standard plugging machines used in the fir industry work very well.

Roddis has tried to use western aspen veneer as a substitute for Douglas-fir. Sharp changes of density throughout its structure caused the panel to become wavy when hot pressed. Testing was limited, but it was found to have some characteristics that make it good core material.

For the last year, cativo has been used for inner plys, and interchangeably with basswood when a soft core material is needed. Cativo lays flat and has a tendency to cause bowing or twisting when glued into thin panels. It has poorer nail-holding power than does elm. Cativo was tried for door crossbands, and it was found that it acts like basswood in most ways. It has, however, a nutty smell when heated that many find objectionable.

Plywood Import and its Effect on United States Plywood Producers

H. C. Fidler, vice-president and general manager, Owens–Illinois Plywood Co., North Troy, Vt., 11th National Meeting, June 23–28, 1957, at Buffalo, New York.

Hardwood plywood manufacturers are having difficulty competing with imports. Programs of modernization, quality control, industrial engineering, integrated logging, and so forth, have been instituted by some manufacturers to place them in a more favorable position.

Foreign imports in 1946 were 20.3 million surface feet. Today, annual imports total 690 million surface feet. Japan ships 510 million surface feet annually. United States manufacturers produce and sell 810 million surface feet each year. In 1951, of all the plywood consumed in the United States, only 7.6 per cent was imported while 46 per cent was imported in 1956. During this period, Japanese imports increased 4,120 per cent. Plywood demand during this period increased 74 per cent, yet the domestic manufacturers received only .006 of 1 per cent of the increase.

The main competitor is Japan. The Japanese manufacturer pays wages of 11½¢ per hour. Japanese log costs are one-third of domestic log costs. Labor cost per M surface feet in Japan is one-eighth of United States labor cost. The Japanese mills have a capacity of 2.4 billion surface feet annually while domestic mills have a capacity of 1.2 billion surface feet.

Many manufacturers are taking steps to offset some of the advantages of foreign imports. For example, Owens–Illinois started early in 1952 on a complete reorganization and modernization program. This program included: integrated logging operation; logs purchased on grade; an industrial engineering program; plant modernization; a quality control program; cost and budget control; selective production and sales; and sponsored quota legislation.

Through integrated logging, the full content of the tree was placed on the market at the best price. By buying logs on grade, it is possible to purchase only grades of logs suitable for manufacturing high-grade veneer. By use of industrial engineering, thousands of dollars were saved, wage increases absorbed, and labor cost per M feet maintained. A modernization program costing thousands of dollars was paid for in 1.2 years, and production was doubled. By use of a quality-control program, rejects were decreased, production increased, yields improved, shipments made on time, and prices were increased or maintained through 1955.

A cost and budget control system proved to be of great benefit. Through this program, complete detailed planning and programs were outlined for each year and for years to come. Objectives in every field were set. Numerous conferences and reviews were held to observe progress. All expenditures were pinpointed.

Through a selective production and selling program, plant production was switched from low-grade items to high-grade items, efforts were directed toward quality, customer service, and direct factory representation, sales costs were reduced 60 per cent, and many new products were introduced. By cooperating with members of Congress, legislation was introduced to limit foreign imports to 15 per cent.

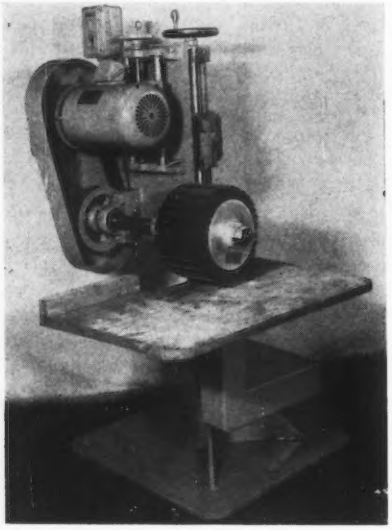
The modernization program maintained a moderate profit through the year 1955, but due to decreased house starts and imports, 1957 will be disastrous for Owens–Illinois as well as for the Hardwood Plywood Industry as a whole. Foreign plywood imports are on the increase and domestic product sales are on the decrease. Domestic production is now greater than demand. Quota legislation is required.

FPRS News-Digest, Continued

NEW PRODUCTS—LITERATURE

New Wood Species Chart

"Comparative Ratings", the fourth in a series of charts designed by Simpson Redwood Co., lists all major commercial wood species and rates them according to ten most important qualities. The chart is 8½ x 22 inches and is printed on heavy cardstock. It is available free from Simpson Redwood Co., Rm. 311, Arcata, Calif.



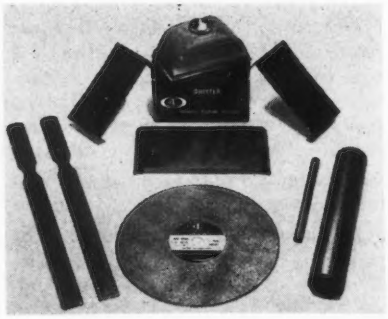
Variable-Speed Drive

A new unit equipped with a variable-speed drive has been announced by the makers of the Vonnegut Universally Adjustable Stand. The new variable-speed drive is said to permit use of buffs, wire brushes, or other types of sanding, cleaning, deburring or polishing devices. Information is available from Grinding & Polishing Machinery Corp., 2530 Winthrop Ave., Indianapolis 5, Ind.

New Emulsion Resin

Polyvinyl chloride-acetate copolymer emulsion is now being marketed by National Starch Products Inc., N. Y. C. In making the announcement, James Dillon, vice-president, stated that the product marketed as Resyn 2507 does not require additives or thickeners to increase viscosity, nor pre-emulsification of plasticizers.

It is reported that it can be plasticized directly by the user with monomeric plasticizers or with acrylic latices. Advantages of the product are said to be good wet tack, exceptional mechanical stability, superior hold-out on porous surfaces and easy sealing heat. Because of its vinyl chloride content, the resin is said to have superior fire-retardant properties.



New Abrasive Grit

Kengrit, a new abrasive grit in standard sizes from 24 to 240 has been developed by Kennametal, Inc. It is reported that when brazed, silver soldered, cemented, or applied to metallic surfaces by other means, the Kengrit particles cut faster than ordinary abrasives and in addition provide smooth finishes on wood. A special manufacturing process is said to obtain hard, sharp cutting edges that will not break or round off.

New Grading Booklet

A new pocket-sized booklet outlining grading rules for pressure-treated fence posts and barn poles has been issued by the Southern Pine Lumber Co. Entitled "Grading Rules for Pressure Treated Fence Posts and Barn Poles—1957 Edition", the booklet discusses the standards established as to material, straightness, manufacture, seasoning, preservative treatment, and grading. Copies of the 8-page booklet SP-GR-1 are available from Southern Pine Lumber Co., Diboll, Texas.

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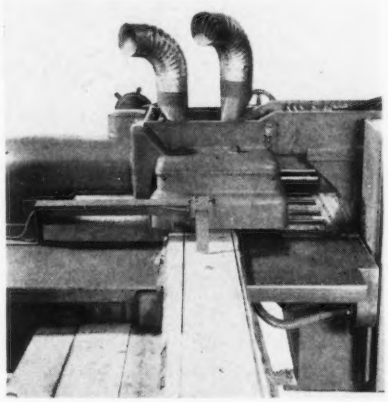
Two-Blade Straightline Ripsaw

Mattison Machine Works recently announced the release of a two-blade straightened ripsaw mounted on an externally-splined mandrel, working through an internally-splined sleeve. This two-saw edger can be set to different predetermined widths to make two saw cuts at once on a given board in such manner as to provide two straight edges.

Traverse of the movable saw blade to different pre-selected positions is governed by means of a pushbutton control station at the ripsawyer's right hand. The station has a separate and plainly marked pushbutton for each predetermined standard width.



Another potential use of this machine is for straightedging one edge and ripping a stipulated width in connection without particular reference to the remaining edge of the board. Minimum width between saw blades is 2½ inches. Maximum width between saw blades is 12 inches. More information can be obtained from Mattison Machine Works, 545 Blackhawk Park Ave., Rockford, Ill.

FOR SALE

1 Baldwin 665 ton, 10 opening steam platen press, Serial No. SO471170, opening 102" x 52". Purchased new in 1948. Manufactured by Baldwin Locomotive Works, Philadelphia, Pa. Machine in daily operation. Can be seen if desired.

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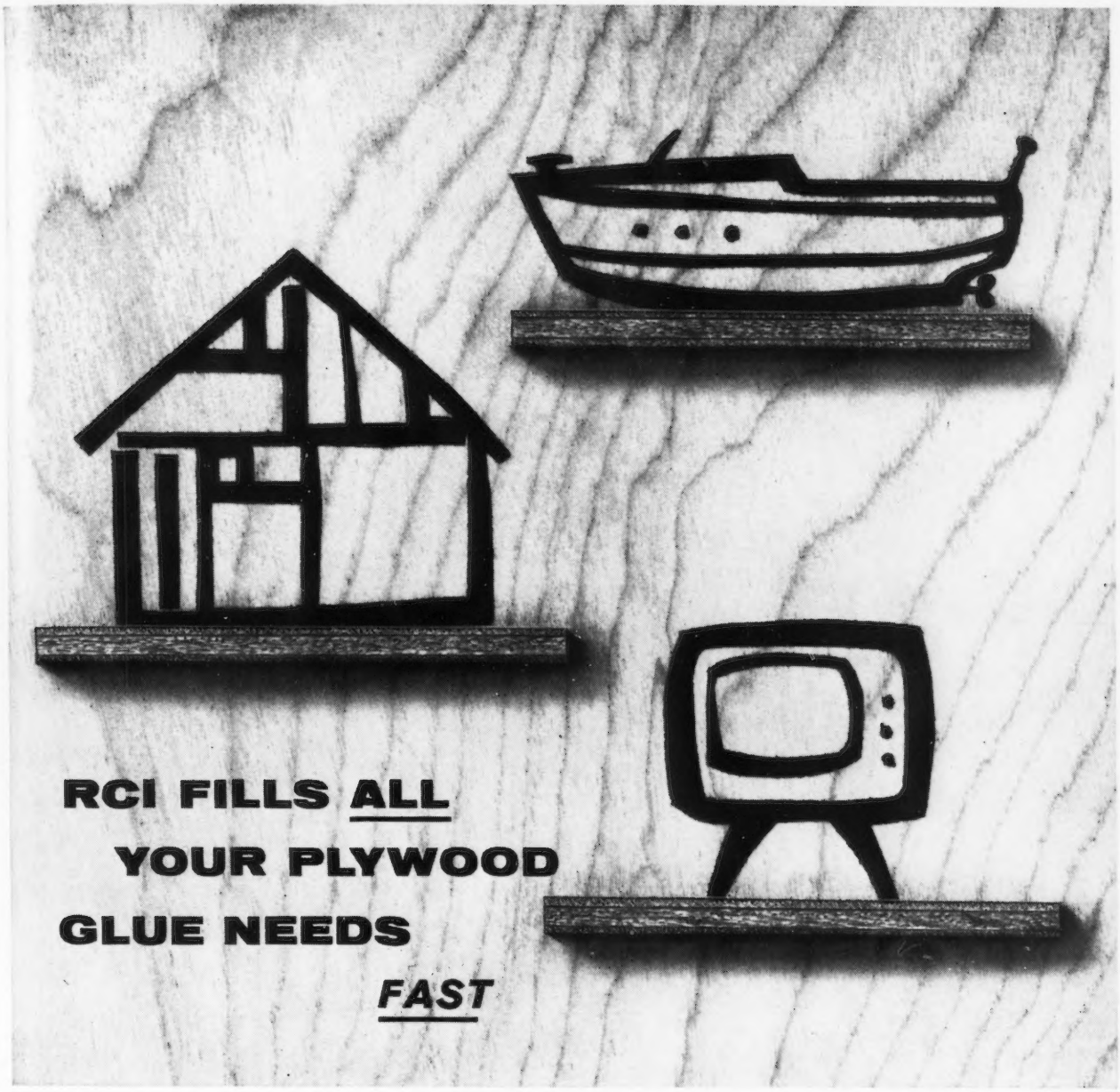

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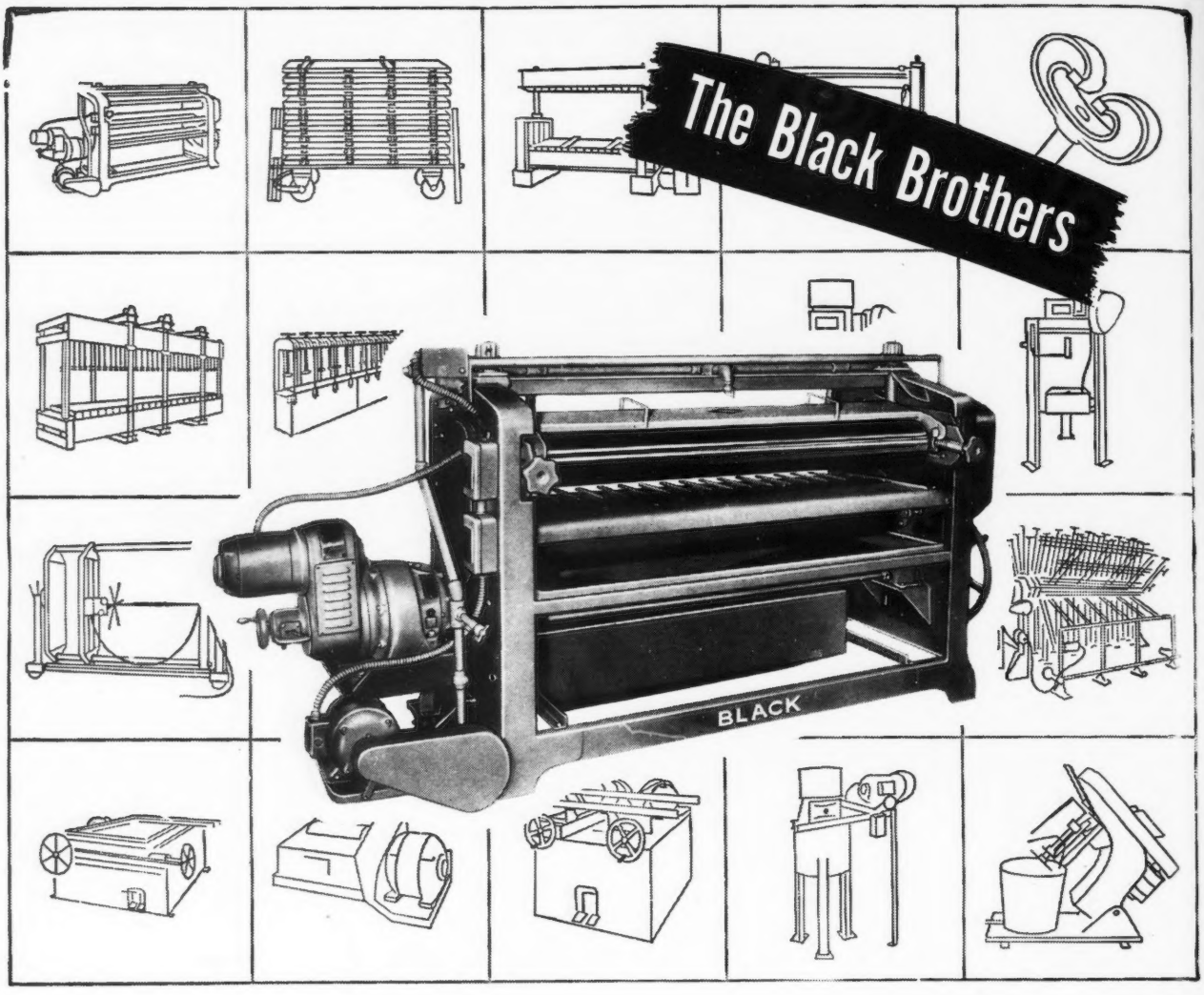

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